MISCELLANEOUS PAPER NO. 6-730

# INVESTIGATION OF CONCRETE AGGREGATES AND RIPRAP, KASKASKIA RIVER, ILLINOIS NAVIGATION IMPROVEMENT

Ьу

B. J. Houston

A. D. Buck

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August 1985

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U. S. Army Engineer District
St. Louis

NATIONAL TECHNICAL INFORMATION SERVICE Springfield Va 22151



Conducted by

U. S. Army Engineer Waterways Experiment Station CORPS OF ENGINEERS

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ARMY-MRC VICKSBURG, MISS

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# FOREWORD

The investigation reported herein was authorized by letter dated 11 March 1965 from U. S. Army Engineer District, St. Louis, subject, "Request for Testing Concrete Aggregate and Riprap, Kaskaskia River, Illinois, Navigation Improvement."

The work was performed at the LMVD Materials and Concrete Laboratory, U. S. Army Engineer Waterways Experiment Station (HES), under the direction of Mr. Thomas B. Kennedy, and the supervision of Messrs.

J. M. Polatty, Bryant Mather, R. L. Curry, W. O. Tynes, E. E. McCoy, A. D. Buck, W. I. Luke, and B. J. Houston, and Mrs. Katharine Mather.

This report was prepared by Mr. Houston and Mr. Buck.

Director of WES during the performance of the investigation and preparation of the report was Colonel John R. Oswalt, Jr., CE.

Technical Director was Mr. J. B. Tiffany

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### SUMMARY

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In order to determine relevant properties of materials present in locally available sources of concrete aggregate and riprap for use in the Kaskaskia River, Illinois, Navigation Improvement project in the St. Louis District, a number of sources were selected for investigation. The coarse aggregate and riprap materials submitted for testing were crushed limestone, and the fine aggregate was a natural sand which was deficient in the fine fractions. A supply of fine sand was submitted for use in making up the size deficiencies. Of the five coarse aggregate sources tested, four were considered as potential suppliers of both riprap stone and coarse aggregate. The other source was considered only as a supplier of riprap.

The results of the examinations and tests indicate that none of the materials contain features or possess properties that render them definitely unsuitable for the purposes for which they were tested. The lower 35-ft ledge of West Lake Quarry, however, contained rock capable of dedolomitization reaction in concrete, and aggregate from this ledge should not be used alone in concrete, but if all three ledges in the quarry are worked simultaneously the resulting aggregate would probably not be expansive in concrete. This aggregate as well as the fine aggregate tested should only be used with low-alkali cement. Rock from the other sources considered as coarse aggregate did not contain dolomite proportions in the reactive range.

Stone from all five sources should be satisfactory for use as riprap provided shaly fractions in some sources are not allowed to become concentrated enough to have an adverse affect on the ability of the stone to withstand severe weather and remain intact in large pieces.

# INVESTIGATION OF CONCRETE AGGREGATES AND RIPRAP. KASKASKIA RIVER, ILLINOIS. NAVICATION IMPROVEMENT

PART I: PURPOSE AND SCOPE

# Purpose

1. The purpose of the work was to determine relevant properties of materials present in locally available sources of concrete aggregate and riprap-for use in the subject project.

# Scope

2. Crushed stone from four quarries was tested for use as both concrete aggregate and riprap. Crushed stone from another quarry was tested for use as riprap. A river sand from Chester, Illinois, and a fine blending sand from Evansville, Illinois, were tested for use as concrete sand.

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# PART II: SAMPLES AND TESTS

# Samples

3. Source information data on samples submitted for testing are as follows:

Gibbar Quarry No. 4

Stace:

Missour1

Latitude:

370

Longitude:

890

Location:

Sec 11, R 12 E, T 35 N, Perry Co.,

Mo., near Red Rock, Mo.

Producer:

Southern River Rock Co., Box 33,

Perryville, Ho.

and age:

Geologic formation Plattin limestone, Middle Ordovician

Age

Remarks:

This hillside quarry is currently worked in two ledges, an upper + 60-ft ledge above the 5- to 6-ft shaly zone and a lower + 45-ft ledge below the shale. The shaly zone is wasted. This quarry has previously supplied shovelrun 5000-1b dike stone and 150-1b riprap

for river projects.

West Lake Quarry No. 5

State:

Missouri

Latitude:

380

Longitude:

900

Location:

Sec 17, R 9 E, T 38 N, Ste. Generieve

Co., Ho., at Little Rock, Mo.

Prod ser:

West Lake Quarry and Material Co., Box 206, Taussig Road, Bridgaton, Mo.

Geologic formation and age:

Ste. Genevieve limestone and St. Louis limestone, Meramec group, Middle Mississippien Age

Remarks:

This open quarry is currently worked in three ledges, an upper + 30-fc ledge in the Ste. Genevieve limestone, a middle + 80-ft ledge, and a lower + 35-ft ledge, all in the St. Louis limestone. This source has previously supplied only 5000-lb shovel-run dike stone for river projects.

# Stotz Quarry

State:

Illinois

Latitude:

380

Longitude:

900

Location:

Sec 16, R 9 W, T 5 S, Randolph Co., Ill. 1/2 mile north of Prairie du Rocher, Ill. Ansonomianos com como de este de la como dela como dela como de la como dela como dela

Producer:

Stotz Quarry, Prairie du Rocher, Ill.

and age:

Geologic formation Salem limestone, Heranec group, Hiddle Mississippian Age

Remarks:

This source currently mines three ledges, an upper + 13-ft ledge, a middle + 10-ft ledge, and a lower + 14-ft ledge. In every ledge the in-place stone appears very similar, and materials in stockpile cannot be easily referred to an individual ledge. In the mine, the upper and middle ledges and the middle and lower ledges are occasionally worked as a unit. In perhaps three years, the operator plans to mine all three ledges in one unit. The crushed stone samples represent the lower + 14-ft ledge. The ledge samples marked No. 1 represent the upper 13-ft ledge and the middle + 10-ft ledge. The ledge samples marked No. 2 represent the lower + 14-ft ledge.

# Charlie Bussen Quarry

State:

Missouri

Latitude:

380

Longitude:

900

Location:

Sec 12, R 8 B, T 38 N, Ste. Genevieve

Co., Mo.

Producer:

Charlie Bussen Quarry, Ste. Genevieve,

and age:

Geologic formation Salem limestone, Heranec group, Middle

Mississippian Age

Remarks:

This open quarry is worked in five ledges, four of which have been previously approved for river projects and are here represented by the ledge samples. 

# Menefee Quarry

State:

**Missouri** 

Latitude:

380

Longitude:

900

Location:

Sec 24, R 7 E, T 39 N, Ste. Genevieve Co., Mo., 1/2 mile southwest of Brickeys,

Mo.

Producer:

Menefee Crushed Stone Co., Inc., P. O.

Box 387, Nashville, Tenn.

and age:

Geologic formation Kimmswick limestone, Middle Ordovician

Age

Remarks:

Two pits are present at this location, an upper, or western pit, and a lower, or eastern, pit. The samples represent the + 15-ft ledge exposed at the lower pit. This source has previously supplied 5000-1b shovel-run dike stone and 150-1b

riprap to river projects.

f. Southern Illinois Send Co. (see M No. 6-370, Vol IV)

Latitude: 37º

Longitude: 890

g. Siegfried Fine Sand

State: Illinois

Latitude: 38º

Longitude: 890

Location: 2-1/2 miles southwest of Evansville,

Ill., Randolph Co., Ill.

Producer: Ruma Asphalt Co., Ruma, Ill.

Geologic formation Residual Cypress sandstone, Upper

and age: Mississippian Age

Remarks: This newly opened pit supplies fine

sand to the Ruma Asphalt Co. Fine sand is excavated in the dry and is loaded directly on trucks, without processing. Two ft of soil overburden is stripped and wasted prior to excavating the under lying 12 ft of fine sand. 4. The material was given the following laboratory sorial numbers.

CD No.	Source ·	<u> Material</u>	Amount
STL-19 G-1	Gibbar Quarry No. 4 near Red Rock, Mo.	6-in. core	26 boxes 4400 lb
STL-19 G-2	West Lake Quarry No. 5, Little Rock landing near Ste. Genevieve, Mo.	6-in. core	32 boxes 5400 lb
STL-19 G-3	Stotz Quarry, Prairie du Rocher, Ill	Crushed stone	5680 1ь
STL-19 G-3(A)		Upper 13- and mid- dle 10-ft ledge .	1600 1ь
STL-19 G-3(B)	5	Lower 14-ft ledge	

CD No.	Source	Meterial	Amount
STL-19 G-4(A)	Charlie Bussen Quarry, Ste. Genevieve, Mo.	Ledge No. 1	3200 lb total
STL-19 G-4(B)		Ledge No. 2	٠.
STL-19 G-4(C)		Ledge No. 3	٠.
STL-19 G-4(D)		Ledge No. 4	
VICKS-35 G-1(2)	Menefee Quarry, Brickeys, Mo.	Ledge stone	8300 1ь
STL-5 S-3(4)	Southern Illinois Sand Co. Chester, Ill.	River send	3600 јь
STL-19 S-1	Siegfried Fine Sand, near Evansville, Ill.	Matural sand	480 lb

# Tests

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- 5. Logging of cores. The cores from Gibbar and West Lake Quarries were logged in sufficient detail to determine if potentially reactive carbonate rock was present. Shaly material representing a 4- to 5-ft zone between the upper 60-ft ledge and lower 45-ft ledge of Gibbar Quarry was logged and then discarded as this zone is wasted during quarrying operations.
- 6. Petrographic examination of ledge rock. Ledge rock from Stotz and Bussen Quarries were examined for presence of potentially reactive carbonate rock.
- 7. Petrographic examination of crushed material and sand. A portion of ledge stone from Menefee Quarry was crushed and recombined according to

OCE Guide Specifications into No. 4 to 3/4-in., 3/4- to 1-1/2-in., and 1-1/2- to 3-in. size groups. A petrographic examination was made of sieve splits of No. / to 3-in. sizes. An examination of splits of Siegfried fine sand was also made.

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- 8. Samples tested for use as riprap. The material from the upper ledge of Gibbar Quarry was separated into two lithological rock types for testing. It was found that the core from the lower ledge was so fractured that it was impossible to get samples for riprap tests. The stone from West Lake Quarry was tested as four lithological types. The stone from Stotz Quarry represented two ledges, the upper ledge was divided into two lithological types for tests; the lower ledge was tested as only one type. The stone from Bussen Quarry represented four ledges. The third ledge was divided into two lithological types, while the other three ledges were tested as one type each. The stone from Menefee Quarry represented one ledge and was tested as one lithological type.
- 9. Each sample or lithological rock type was subjected to the following tests, using applicable procedures from the Handbook for Concrete and Cement:
  - a. Specific gravity (unit weight) and sbsorption, CRD-C 107.

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- b. Abrasion, grading E, CRD-C 117.
- c. Toughness, CRD-C 132.
- d. Freezing and thawing, CRD-C 144.
- 10. Acceptance tests for use as concrete aggregate. Samples of stone from Gibbar, West Lake, Stotz, and Menefee Quarries were tested

for use as concrete aggregate. Three size groups were tested which were No. 4 to 3/4-in., 3/4- to 1-1/2-in., and 1-1/2- to 3-in. Each size group from each quarry, where applicable, was subjected to the following tests:

- a. Sieve analysis, CRD-C 103.
- b. Specific gravity and absorption, CRD-C 107.
- c. Soundness, CRD-C 115.
- d. Abrasion, CRD-C 117.

- e. Flat and elongated, CRD-C 119.
- f. Scratch hardness, CRD-C 130.
- 11. The Seigfried and Southern Illinois fine aggregate were subjected to the following physical tests:

- a. Sieve analysis, CRD-C 105, CRD-C 103,
- b. Specific gravity and absorption, CRD-C 108.
- c. Organic impurities, CRD-C 121.
- d. Mortar-making properties, CRD-C 116.
- 12. Freezing and thawing of concrete aggregate. The No. 4 to 3/4-in. fractions of the material from Gibbar, West Lake, Stotz, and Menefee Quarries were tested in combination with Southern Illinois and Siegfried sand according to test method CRD-C 114.

### PART III: RESULTS AND CONCLUSIONS

# Results

13. Logging of cores. Cores from Gibbar and West Lake Quarries were logged and the results are given in the petrographic report, WES Form 1115. The log indicated that the core from Gibbar Quarry, which is worked in two ledges, was primarily dolomite. The core from the lower ledge had an abundance of vertical fractures and closely spaced bedding planes which prevented testing of this material for use as riprap. Except for the bottom 3.5 ft of the core from the lower ledge, the dolomite contents of the core from both ledges fell outside the range in which deleterious dedolomitization occurs. Core from the upper ledge of West Lake Quarry, which is worked in three ledges, was primarily oolitic and dense limestone with a little shaly limestone and clay, while that of the middle ledge was dense and dolomitic limestone with some stylolitic limestone and scattered layers of shale, and that from the lower ledge was oolitic and dense limestone and fine to medium grained dolomitic limestone. The rock in the upper ledge should not be subject to dedolomitization if used as concrete aggregate. Properties of dolomite and calcite in the core from the middle ledge indicated probable potential reactivity and this was confirmed by testing small 0.35-in.-diameter cores drilled from the larger cores for length change in 1-N NaOH. The expansion of the small cores indicates that rock from depths 90 to 104 ft, which probably represents the top of the lower 35-ft ledge, would

produce expansive reaction in concrete; however, if all three ledges are simultaneously quarried, the resulting aggregate would not be sufficiently expansive to be harmful in concrete. The core from the lower ledge was highly fractured, but this is not caused by bedding planes and is probably a localized condition.

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14. Petrographic examination of ledge rock. None of the ledge rock from Stotz Quarry, which was from three separate ledges, contained calcite-dolomite in proportions regarded as dangerous. This material was mainly dense limestone with a moderate amount of shally limestone. Ledge rock from Bussen Quarry, representing four ledges, was found to be mainly dense limestone with a moderate amount of shale, especially in ledge 3. This material would not be expansive in concrete. The ledge rock from Menefee Quarry represented one ledge and was limestone. This material would not be expansive in concrete.

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- aggregate of 3-in. maximum size from Bussen Quarry was examined. This material is expected to produce suitable concrete aggregate. The Siesfried fine sand was examined and found to be primarily quartz with about 10 percent chert. If the volume of this sand used in concrete is such that the chert amounts to 5 percent or more of the fine aggregate, low-alkali cement should be specified.
- 16. Samples tested for use as riprap. Samples of rock from Gibbar, West Lake, Stotz, Bussen, and Menefee Quarries were tested for use as riprap. The results are given in table 1 and on inclosed WES Forms 726

and 1115. The material from the upper ledge of Gibbar Quarry was satisfactory in all tests except the dolomite had a slightly high absorption (1.7), and the effect of freezing and thawing was greater than for the other four sources tested. Samples from the lower ledge were not tested because of its fractured condition. The rock from West Lake Quarry was satisfactory in all tests except the toughness test of the dense limestone. The rock from Stotz Quarry was satisfactory in all tests. The material from Bussen Quarry was satisfactory in all tests except the rock from ledge 1 and the shaly limestone from ledge 3 had a slightly high absorption. The rock from Menefee Quarry had a high abrasion loss and failed the toughness test. It was, however, perhaps the least affected by freezing and thawing of all sources tested and was the most uniform material.

17. Acceptance tests for use as concrete aggregate. Samples of stone from Gibbar, West Lake, Stotz, and Menefee Quarries were tested for use as coarse aggregate in concrete and the results are shown in table 1 and on WES Forms 726 and 477. All stone was satisfactory except the stone from Menefee Quarry and the No. 4 to 3/4-in. size group of the stone from Stotz Quarry which exhibited a slightly high abrasion loss (CRD-C 117), and the stone from Menefee Quarry also had a high percentage of soft particles. Samples of Mississippi River sand (STL-5 S-3(4)) and fine blending sand (STL-19 S-1) were given abbreviated tests for use as concrete sand. The river sand was found to contain organic impurities as shown by CRD-C 121, but strength tests indicate that these did not have a significant effect in reducing strength of mortar made with it.

18. Freezing-and-thawing test of concrete aggregate. The results of the freezing-and-thawing tests are as follows:

<u>Material</u>	DEE 300
Stotz	81
Menefce	81
West Lake	80
Gibbar	71

The material from Stotz, Menefee, and West Lake Quarries withstood freezing and thawing slightly better than the material from Gibbar; however, the material from all four sources appears to be of such a nature as not to acversely affect the resistance to freezing and thawing of concrete containing it.

# Conclusions

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- 19. Riprap. The bedding of the limestone from all five quarries is thick enough to allow production of blocks massive enough for riprap.

  Rock from the Menefee and Bussen Quarries were least affected by freezing and thawing. The results of the examinations and tests indicate that riprap not possessing undesirable properties can be produced from all the sources evaluated provided the shally limestone portions are wasted.
- 20. Concrete coarse aggregate. The results of examinations and tests indicate that concrete aggregate free of undesirable properties can be produced from all the sources evaluated.
- 21. Concrete fine aggregate. A blend of the two fine aggregates tested would probably contain enough alkali-silica reactive ingredients

to make it mandatory that low-alkali cement be used in concrete containing these aggregates. With low-alkali cement these fine aggregates would not be expected to manifest unsatisfactory performance in concrete.

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Test Results of Stone from Proposed Sources of Riprap Kaskaskia River, Illinois, Navigation Improvement

	41.14				Toughness, Height, cm. Perpendicular Parallel	Parellel	% Loss F&T in Alcohol
	SP Gr	Unit We,	Absorp.	Abrasion Loss, %	to Joint Plane	to Joint Plane	and Water 20 Cycles
Gibbar Quarry No. 4 STL-19 G-1							
Dense Limestone	2.69	167.6	4.0	28.5	۲.	<b>S</b>	* ;
Dolomíte	2.68	167.0	1.1	30.9	_		13.0
West Lake Quarry No. 5 STL-19 G-2							•
Dense Limestone	2.66	167.5	0.3	33.4	~	4	6.8
Colitic Limestons	2.65	165.1	0.2	24.9	Φ,	•	0.1
Soft Weathered	•			•	•		
Limestone	2.52	157.0	2.5	30.1	••	so.	
Shaly Limestone	2.67	166.3	0.5	31.0	11	Φ.	0.6
Stots Quarry STL-19 G-3(A)							
Dence Limestone	2.67	166.3	9.0	32.8	^	~	6.0
Shaly Limestone STL-19 G-3(B)	2.66	165.7	9.0	. 25.8	, ,	€	4.6
Dense Limestons	2.68	167.0	4.0	29.8	••	7	4.0
* One of the three samples of 0.3 and 6.0 percent.		ntegrated	at 17 cycles	; the other	disintegrated at 17 cycles; the other two had a weight loss at 20 cycles	ht loss at	20 cycles
					•		

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Test Results of Stone from Proposed Sources of Riprap (Continued)
Kaskaskia River, Illinois, Navigation Improvement

	4			•	Toughness, Height, cm.	ight, cm,	Z Lone
	SP Gr	Unit Wt,	Absorp.	Abraeton	rerpendicular to Joint	Perallel to Joint	Alcohol and Water
Bussen Querry STL-19 G-4(A)				4 1007		au Ta	20 Cyc 1 6 8
(Ledge No. 1)	•	,		•			
Dense Limestone STL-19 G-4(B)	2.61	162.6	1.6	26.6	^	•	4.0
(Ledge No. 2)							
Dense Limestone	2.64	164.5	0.7	24.7	•	ø	•
STL-19 G-4(C)					•	h	•••
(Ledge No. 3)							
Dense Limestone	2.61	162.6	1.1	28.4	•	•	•
Shaly Limestone	2.61	162.6	1.5	28.5	~	) <b>~</b>	• • • •
(Ledge No. 4)						•	•
Dense Limestone	2.62	163.2	0.7	28.9	_	••	0.2
Menefee Quarry		`					
Danse Linestone	2.62	163.2	o.e	. 35.4	'n	~	0.5

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TABLE 2
Test Results of Proposed Sources of Concrete Aggregate
Kaskaskia River, Illinois, Navigation Improvement

Gibbar Quarry No. 4	Bulk Sp Gr SSD	Absorp.	Thp.	Soft Particles,	Flat and Elongated	Mg SO4 Loss,	Abrasion Loss,	Freezing and Thaving in Concrete DFE 300
STL-19 G-1 1-1/2 - 3 in. 3/4 - 1-1/2 in. No. 4 - 3/4 in.	2.70 17.2	 		000	6.24 6.34		30.8 36.6 84.6	
West Lake Quarry No. STL-19 G-2 1-1/2 - 3 in. 3/4 - 1-1/2 in. No. 4 - 3/4 in.	2.68 2.67 2.67	980		9.4.9 9.6.6	4.04 14.04 4.74	13.4	30.2 29.1	8
Stotz Quarry STL-19 G-3 1-1/2 - 3 in. 3/4 - 1-1/2 in. No. 4 - 1/4 in.	2.68 68 68 68	4.00	• • •	0.00	0 i 6 4 6 6	1 1 80	25.3 43.6 43.9	٠٠
Menefee Quarry VICKS-35 G-1(2) 1-1/2 - 3 4m. 3/4 - 1-1/2 1m. No. 4 - 3/4 1m.	2.62 2.62 2.61	720		 	0.0 7.3 1.9	′ , , , ,	43.8 51.2 44.0	* * 56

\* Poor particle shape probably resulted from testing samples from crushed 6-in. cores.

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Corps of Engineers, USAE Waterways Experiment Sta	Petrographic Report	Concrete Division P. O. Drawer 2131 Jackson, Mississippi
Project: Kaskaskia River, Illinois	, Navigation Improvement	Date: 28 May 1965
Memo:	Job:	Initials:
1441	441-6624	ADB, WIL, JH, KM

# Semples

1. Samples of carbonate rocks from five quarries and two natural sands are listed and identified below:

CD		
Serial No.	Source	Type and Amount
STL-19		in .
G-1	Gibbar Quarry No. 4, near Red Rock, Mo.	6-in. core
G-2	West Lake Quarry No. 5, Little Rock Landing, near Ste. Genevieve, Mo.	Three 6-in. cores
G-3	Stotz Quarry, Prairie du Rocher, Ill.	Crushed stone
G-3(A)	Same - upper 13- and middle 10-ft ledge	Ledge rock
G-3(B)	Same - lower 14-ft ledge	Ledge rock
G-4(A)	Charlie Bussen Quarry, Ste. Genevieve, Mo.	Ledge No. 1
G-4(B)	Same	Ledge No. 2
G-4(C)	Same	Ledge No. 3
G-4(D)	Same	Ledge No. 4
VICKS-35 G-1(2)	Menefee Quarry, Brickeys, Mo.	Ledge rock
STL-5 S-3(4)	Southern Illinois Sand Co., Chester, Ill.	Natural sand
STL-19 5-1	Siegfried Fine Sand, near Evansville, Ill.	Natural sand
Rock	from all of the quarries except the Charlie Bussen	Quarry, Ste.
Genev	ieve, Mo., was tested as riprap and coarse aggregat	e. Rock from
the C	harlie Bussen Quarry was tested as riprap.	

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# Test Procedure

NAME OF THE PARTY OF THE PARTY

- 2. Core logs. Cores from Gibbar Quarry (STL-19 G-1) and West Lake Quarry No. 5 were logged. The surfaces were tested for differences in hardness and washed with dilute hydrochloric acid to emphasize lithologic changes. Samples of each lithologic variety were selected for test according to CRD-C 144, Method of Testing Stone for Resistance to Freezing and Thawing and for other riprap tests.
- 3: Ledge rock. STL-19 G-3(A), G-3(B), G-4(A) through G-4(D), and VICKS-35 G-1(2) were examined, using dilute hydrochloric acid and a steel needle to emphasize lithologic differences. Samples of each variety were selected for test according to CRD-C 144 and for other riprap tests.
- 4. Screening tests for dedolomitization reaction. Lithologic varieties in cores STL-19 G-1 and G-2, and in ledge rock STL-19 G-3(A) and (B), and the variety making up VICKS-35 G-1(2) were taken to determine whether alkalicarbonate reactive varieties were present. The screening tests consist of the following:

- a. A representative sample of each lithologic variety was handground and scanned on the diffractometer as a tight-packed powder. Samples consisting entirely of calcite or entirely of dolomite were eliminated from additional testing on the basis of these results.
- b. If a variety had dolomite-calcite proportions in or near the reactive range, a sample was ground to pass No. 325 sieve. Each powder was compressed in an aluminum ring at 2000 lb; the compressed specimen was mounted

in the deffractometer and the relative intensities of the calcite and dolomite peaks were scaled. The intensity data were referred to the Tennant and Berger\* curve to determine the amount of dolomite in the carbonate portion of each sample.

- c. If dolomite was 30 to 70 percent of the total carbonate, and the rock was fine grained, cores approximately 1-1/4 in. long and 0.35 in. in diameter were drilled, shaped to have truncated conical ends, and prepared for length-change measurements during storage in 1-N NaOH.
- d. If a variety was selected for length-change measurements, a representative weighed sample was dissolved in dilute hydrochloric acid. The weight of washed insoluble residue was determined and the insoluble residue was scanned on the diffractometer to determine its composition.

# Petrographic examination

5. Menefee Quarry (VICKS-35 G-1(2)). Part of the ledge rock was crushed and processed to make aggregate in the size ranges No. 4 to 3/4-in., 3/4-to 1-1/2-in., and 1-1/2- to 3-in. A representative sample of each fraction was examined. The samples were washed and some particles were examined under the stereomicroscope before and after etching with dilute hydrochloric acid. The visual examination and stereomicroscope examination of the crushed aggregate confirmed the conclusion reached during the examination of the

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<sup>\*</sup> Tennant, C. B., and Berger, R. W., "X-Ray Determination of the Dolomite-Calcite Ratio of a Carbonate Rock," American Mineralogist, Vol 42, Nos. 1 and 2 (1957), pp 23-29.

ledge rock, that the sample could be treated as one lithologic variety; therefore, no particles counts of the crushed aggregate were made. X-ray diffraction patterns were made of a slab of fine grained rock, of a slab of the medium grained rock, and of a sample of the porous grayish-orange\* dolomitic material that formed patchy areas in some of the rock. Two thin sections were made and examined, one from the opposite surface of the x-rayed slab of medium grained rock, and one from a piece containing porous dolomitic material. An immersion mount of calcareous chert was examined in an immersion oil of index of refraction 1.544 to determine whether the chert was chalcedonic.

- 6. Siegfried Fine Sand (STL-19 3-1). Representative parts of fractions retained on No. 100 and No. 200 sieves were examined under the stereomicroscope and tested with dilute hydrochloric acid to verify the presence of carbonate grains. Immersion mounts of each sieve fraction were prepared in immersion oil of refractive index 1.544, and at least 300 grains of each sieve fraction were classified and counted using a polarizing microscope.
- 7. X-Ray Diffraction Conditions. All X-ray scans were made on a diffractometer using nickel-filtered copper radiation at 27 KVCP and 41 ma or at 50 KVCP and 21 ma, as appropriate, with the rate meter setting at full scale equal to 0 4000 counts/sec.

<sup>\*</sup> The Rock-Color Chart Committee, National Research Council, Rock-Color Chart, Washington, D. C., 1948.

# Results

7. Core from Gibbar Quarry (STL-19 G-1). Fig. 2 is the log of the core from this quarry. The rock from 37.5 ft to 118.3 ft was fairly similar in appearance and texture, although it varied in composition. The rock from 127.7 ft to 158.2 ft was more fractured than the rock from the upper ledge, and differed in texture from it. The rock in the footage between 37.5 ft and 118.3 ft -- the upper ledge -- was classified as follows:

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Lithologic type	Footage	Percent of total
Dolomite	29.8	
	$\frac{4.7}{34.5}$	42.7
Dolomitic limestone	9.6	11.9
Slightly dolomitic limestone	36.7	45.4
Total	80.8	100.0

The rock in the footage from 127.7 to 158.2 was classified as follows:

Lithologic type	Footage	Percent of total
Dolomite	13.0 10.2 4.4 27.6	90.5
Shaly dolomite	2.5	8.2.
Limestone	0.4	. 1.3
Total	30.5	100.0

The dolomite of the upper ledge was mottled tan to brownhish gray\* dolomite

<sup>\*</sup> Rock-Color Chart.

with chert nodules and seams resembling stylolites but composed of earthy dolon. te. The mottled areas were softer than the matrix surrounding them. The dolomitic limestone and slightly dolomitic limestone, which were referred to as limestone in the riprap tests, contained closely spaced patches parallel bedding and areas resembling stylolites but composed of dolomite. All of the slabs tested according to CRD-C 144 from this core came from the upper ledge, because the abundance of vertical fractures and closely spaced bedding planes in the lower ledge did not permit obtaining slabs of adequate size for this test.

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- 8. The rock from the lower ledge was predominantly dolomite, as the tabulation above shows, but it was predominantly fine grained hard massive dolomite with occasional paper-thin shale seams, some vuggy regions, a smaller proportion of mottled dolomite than in the upper ledge, and many vertical fractures.
  - 9. The dolomite content of samples from various depths are shown below:

Depth, ft	Dolomite, Percent of Carbonate Portion
40.3 - 46.7	above 95
74.7 - 74.9	above 90
85.2 - 85.4	13
113.0 ~ 113.3	13
129.5 - 129.9	above 95
138.2 - 138.4	above 95
147.7 - 148.1	50 approx.

Except for the 3.5 ft of core represented by the last sample listed, dolomite contents fell outside the range in which deleterious dedolomitization reaction has been reported. Therefore, no additional screening tests of dedolomitization

potential were regarded as necessary.

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- 9. West Lake Quarry No. 5 (STL-19 G-2). Three cores from this quarry -cores WSG/1, WSG/1A, and WSG/1B -- are shown in fig. 3 through 5. WSG/1 is
  believed to represent the upper ledge, WSG/1A to represent the middle ledge
  and bottom ledge, and WSG/13 the lower ledge. Except for differences in
  amount of fracturing, the bottom of WSG/1A and WSG/1B are correlated, and
  thus the bottom of WSG/1A is believed to have penetrated the same rock as
  that represented by WSG/1B.
- 10. The lithologic varieties recognized in WSG/1, from 9.0 to 35.8 ft were:

Lithologic type	Footage	Percent of Total
Oblitic limestone	9.8	36.6
Massive dense limestone	11.6	43.3
Porous limestone	0.3	1.1
Shaly limestone or calcarous shale	1.7	6.3
Clay, core loss	3.4	12.7
Total	<b>26.</b> 8	100.0

The politic limestone was light brownish-gray\*, medium-grained, and dense.

The massive dense limestone was brownish-gray\* fine to medium grained usually fossiliferious and dolomitic in part, with some scattered chert. Brownish-gray\* shally limestone or dolomitic limestone contained many closely spaced shale scans and graded into calcareous shale. Except for a shally zone from

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<sup>\*</sup> Rock-Color Chart.

about 24.0 to 26.5 ft, the rock was massively bedded. X-ray determinations of the dolomite content of samples from depths shown below gave the following results:

Lithologic variety*	Depth, ft	Dolomite
Oolitic	13.7	Not detected
Oolitic	14.6	Trace
Shaly	24.6	Not detected
Shaly	25.3	Not detected
Dense dolomitic	28.0	Not detected
Oolitic	30.5	Trace
Dense dolomitic	32.8	Not detected
Dense dolomitic	35.8	Not detected

<sup>\*</sup> As identified during logging; the variations between non-dolomitic and partly dolomitic limestone were difficult to select visually.

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The rock represented by this core should not be subject to dedolomitization if used as concrete aggregate. Colitic limestone from this core was sampled for riprap tests.

11. The lithologic varieties recognized in cores WSG/1A and WSG/1B were:

	WSG/	1A <sup>(a)</sup>	WSG/IB(a,b)			
Lithologic variety	ft	percent	ft	percent		
Oolitic limestone	1.0	0.9				
Dense fine to medium-grained limestone (+ fossils or chert)	50.5	46.5	3.1	20.7		
Same as above but with scattered layers of shale	12.1	11.1				

(Continued)

# (Continued)

	WSG	/1A <sup>(a)</sup>	WSG/18 <sup>(a,b)</sup>			
Lithologic variety	ft	percent	ft	percent		
Light gray fine-grained dense limestone with scattered chert nodules	11.0	10.1	•	•		
Gray medium-grained stylolitic limestone	6.8	6.3	•			
Sub-lithographic stylolitic limestone or dolomitic limestone	2.9	2.7	3.3	22.0		
Fine to medium grained dolomitic limestone	23.0	21.2	8.1	54.0		
Chert	0.6	0.6				
Shale	0.6	0.6	0.5	3.3		
Total .	108.5	100.0	15.0	100.0		

<sup>(</sup>a) Hole WSG/1A represented material between 0.0 to 108.5 ft. The core from hole WSG/1B represented material from 0.0 to 15.0 ft. Elevations at tops of holes not given.

12. Core WSG/1A. This core contained all of the lithologic varieties tested for riprap. In screening the core for potential alkali carbonate reaction, dolomite contents were determined as shown below. At four distributed depths where properties of dolomite and calcite indicated potential reactivity, the amount and nature of insoluble residue were determined and 0.35-in.-diameter cores were tested for length-change in 1-N NaOH. Determinations of dolomite content and of amount and type of insoluble residue appear below, and length-change determinations of cores from four depths are reported in table 1 and fig. 6.

<sup>(</sup>b) The top 5 ft of this core was rubble. There were vertical fractures between 5.0 to 10.0 ft and between 14.0 to 15.0 ft.

,	Composition of	Insoluble Residue	•	•	,		•	Clay-mica, quartz	•	•	•	•	Clay-mica, quartz	Clay-mica, quartz	•	•	• ,	•	•	Clay-mica, quartz, kaolin		•
Acid	Insoluble	Residuc, 7	•	•	•	•	•	2.5	•	•	•	•	4.2	5.0	•	•	•	•		3.2	•	•
	Dolomite,	2	Æ	£	CN	S	¥95	53	<b>7</b>	Ž	QX QX	£	53	79	50 approx	53	50 auprox	50 approx		23	£	£
		Depth, ft	5.0	14.3	29.0	40.0	51.0	55.0	57.0	58.5	64.0	69.0	0.06	0.46	100.5	102.0	102.8 - 103.0	103.5		103.9	104.5	107.0
		Lithologic Variety	Dense cherty limestone	Dense cherty limestone	Dense cherty limestone	Dense cherty linestone	Dolonite	Dense dolomitic limestone	Dolonte	Dolomite	Dense 11mestone	Dense 1 fmestone	Soft dolomitic limestone	Soft dolomitic limestone	Dense dolomitic limestone	Dense dolomitic itmestone	Dense dolomitic linestone	Dense dolomitte limestone	Dense dolomitic limestone,	sublithographic	Dense limestone .	Dense 1tmestone

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The expansions up to 28 days of the cores from depths 90 to 103.9. ft indicate that it would probably produce an expansive reaction in concrete in which it was used as aggregate.

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- 13. Core WSG/1B. This core was described as representing the lowest working ledge, but while its thickness was reported as over 35 ft, only 15 ft of core was received, of which the top 10 ft was rubble and highly fractured rock. Rock of the core was very much like rock in WSG/1A in the depths below 90 ft. X-ray determinations of dolomite content in rock from depths 2.5, 5.8, 9.5, 10.0, 13.9, and 14.0 14.5 ft all indicated about 50 percent dolomite.
- 14. Stotz Quarry (STL-19 G-3(A)) .3(B)). Ledge rock samples STL-19 G-3(A), representing the upper 13-ft and middle 10-ft ledges, and STL-19 G-3(B), representing the lower 14-ft ledge in the quarry were examined. None of the rock contained calcite-dolomite proportions regarded as dangerous.

- a. STL-19 G-3(A). The sample consisted of 14 tabular and pyramidal pieces ranging from 10 by 7 by 6 in. to 15 by 12 by 6 in., with the average about 12 by 10 by 8 in. The rock was pale yellowish-brown\*, fine to medium-grained limestone which graded into fine-grained colitic limestone. Four blocks contained enough shall seems and stylolites to be called shall limestone. The riprap tests were made on two varieties, dense limestone and shall limestone.
- b. STL-19 G-3(B). The 14 pieces of this sample resembled STL-19 G-3(A)

<sup>\*</sup> Rock-Color Chart.

in size, shape, and composition, but did not contain shaly limestone. The riprap tests were made on dense limestone only.

- 15. Bussen Quarry (STL-19 G-4(A) through G-4(D)). The sample from this quarry consisted of 14 ledge-rock blocks from Ledge 1 (G-4(A)), 16 from Ledge 2 (G-4(B)), and 20 each from Ledge 3 (G-4(C)) and Ledge 4 (G-4(D)), for riprap tests. The sizes of blocks ranged from 7 by 7 by 4 in. to 14 by 9 by 7 in., with the everage about 13 by 7 by 5 in.
- a. Blocks from Ledge 3 were all tabular, but those from the others included some blocky and some tabular. The sample from Ledge 1 included some blocks with partial rusty coatings. Part of the blocks were light olive-gray\*, fine-grained colitic limestone like part of the sample from the Stotz Quarry (STL-19 G-3(A)). The rest was moderate yellowish-brown\*, fine-grained dolomitac limestone; this rock contained many fossil fragments recrystallized to single crystals. Riprap tests were made on one variety, dense limestone.

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- b. Rock from Ledge 2 was pale yellowish-brown\*, dense limestone with single crystal fossil fragments in a fine-grained matrix that contained more stylolites than rock of Ledge 1. Riprap tests were made on one variety, dense limestone.
- c. Ledge 3 was represented by 16 blocks of dense limestone and 4 of shaly limestone. The rock was generally similar to that from Ledge 2, but was lighter in color, finer-grained, and contained fewer single crystal fossils.

  Riprap tests were made on two varieties, shaly limestone and dense limestone.
  - d. Ledge 4 was represented by 19 blocks of dense and 1 of shaly

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<sup>\*</sup> Rock-Color Chart.

limestone. Most of the blocks had partial clay coatings. The rock was light olive-gray\*, fine grained, and somewhat colitic like part of the rock from Ledge 1.

- 17. Menefee Quarry (VICKS-35 G-1(2)). There were about 200 pieces of medium-grained limestone ledge rock in this sample. Most of the pieces were blocky, and about 12 by 11 by 6 in. in size, with a size range from 8 by 6 by 5 in. to 21 by 12 by 10 in. Most of the blocks were yellowish-gray\* with about one-quarter of the blocks light ofive-gray\* with scattered regions of soft grayish-yellow\* porous rock; there were a few light olive-gray\* blocks. The sample was regarded as one variety for riprap tests; all the slabs tested according to CRD-C 144 were the yellowish-gray\* variety.
- 18. After the samples for riprap tests had been chosen, the remainder was crushed to produce aggregate of 3-in. maximum size. The particle shape was blocky with well-rounded corners and edges in the larger sizes, with tabular pieces increasing in the smaller sizes. All of the color variations were expected to behave alike in concrete.
- 19. The yellowish-gray\* limestone making up most of the sample included two varieties. The predominant one was medium-grainedlimestone made up of anhedral calcite grains, containing many small discrete voids which were resionsible for the low bulk specific gravity of the rock. Part of the rock was highly fossiliferious and contained vugs partially filled with calcite crystals; some contained limonitic stylolites or had limonitic surface coatings. The minor variety was fine-grained dense limestone which contained

<sup>\*</sup> Rock-Color Chart.

about 10 percent dolomite, a small amount of quartz grains and chert, and occasional black stylolites.

- 20. The light olive-gray\* limestone was like the medium-grained yellowish-gray\* limestone but contained iron oxides, including limonitic stylolites and limonite disseminated through the rock. Soft powdery red hematite coated surfaces and also was disseminated through the rock.
- 21. The light olive gray\* fine-grained limestone contained scattered regions of soft porous orange material composed of dolimite with calcite, chert, and clay mica, and inconspicious regions of calcareous chert. The chert was not chalcedonic.
- 22. The varieties in this sample were recrystallized calcarenites, showing differing amounts of recrystallization, possibly related differences in grain size, and various concentrations of iron oxide.

- 23. <u>Siegfried Fine Sand</u> (STL-19 S-1). The sample was a clean quartz sand (table 2); all passed the No. 50. sieve.
- a. Quartz. Quartz was the major constituent in irregular or block grains with angular edges. Some of the grains were well-rounded blockly particles.
- b. Chert. Chert, including some with an index of refaction below 1.544, made up 10 percent of the sand.
- c. Feldspar. Fresh and altered plagioclase and potassium feldspar were minor constituents.

<sup>\*</sup> Rock-Color Chart.

d. <u>Miscellaneous</u>. Micas-muscovite, biotite, glauconite, carbonate fragments, green hornblende, and garnet grains, and other mineral and rock grains were classified here.

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#### Summary

#### Riprap

24. A 6-in.-diameter core from Gibbar Quarry No. 4 (STL-19 G-1) and three 6-in.-diameter cores from West Lake Quarry No. 5 (STL-19 G-2) were logged (fig. 1 through 4). Ledge rock samples from Stotz Quarry (STL-19 G-3(A), (B)), Charlie Bussen Quarry (STL-19 G-4(A) through (D)), and Menefee Quarry (VICKS-35 G-1(2)) were examined. Important lithologic varieties in each sample were chosen for physical tests. The bedding of all the limestone was thick enough to allow production of blocks large enough for riprap. Rock from the Menefee Quarry (VICKS-35 G-1(2)) and Bussen Quarry (STL-19 G-4(A) through (D)) were least affected by freezing and thawing (CRD-C 144).

#### Coarse aggregate

25. All of the samples tested as riprap, except STL-19 G-4(A) through (D) from Bussen Quarry, were considered as coarse aggregate. Screening tests were made of all four to detect rock capable of the dedolomitization reaction in concrete. Rock from depths of 90 through 104 ft in core WSG/1A, West Lake Quarry No. 5 (STL-19 G-2) contained proportions of dolomite in the reactive range and expanded where stored in 1-N NaOH (table 1, fig. 5). Rock from this zone probably represents the top of the lower 35-ft ledge. If all three ledges were simultaneously quarried, the resulting aggregate would probably not be expansive in oncrete. Rock from the other sources considered as coarse aggregage did not contain dolomite proportions in the reactive range.

# Fine aggregate

26. The fine blending sand (STL-19 S-1) contained 10 percent chert, including some chalcedonic chert. If the sand were used in amounts such that chert amounted to 5 percent of the fine aggregate, low alkali cement should be specified to avoid the possibility of deleterious alkali silica reaction.

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- 1-2. Tables
- 3-8. Figures

Table 1

Length Change; Limestone Cores (STL-10 G-2)

Depth,	Lithologic	Speci- men	Percen	t Length	Change	at Ages	Below(a)
ft	Variety	No.	7	14	21	28	56
55	Dense dolomitic	1	-0.015	-0.008	-0.030	-0.030	-0.046
	limestone	2	-0.016	-0.023	-0.031	-0.039	-0.031
90	Soft dolomitic	1	0.032	0.024	0.024	0.056	0.056
	limestone	2	0.066	0.088	0.081	0.081	0.110
94	Soft dolomitic	1	0.047	0.055	0.047	0.455	0.078
	limestone	2	0.043	0.007	0.021	0.093	0.100
103.9	Dense dolomitic	1	0.049	0.082	0.066	0.115	0.140
	limestone	2	0.079	0.165	0.197	0.221	0.291

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<sup>(</sup>a) Shrinkage is indicated by a minus sign.

Table 2

# Composition of Siegfried Fine Sand (STL-19-5-1) from Ruma Asphalt Co., Ruma, Ill.

Constituents	Amount in on Sieves	Weighted Avorage Composition(b)		
Quartz	No. 100 68	<u>No. 200</u> 75	74	
Chert	14	9	10	
Feldspar	7	6	6	
Miscellancous(c)	_11	10	10	
Total	100	100	100	

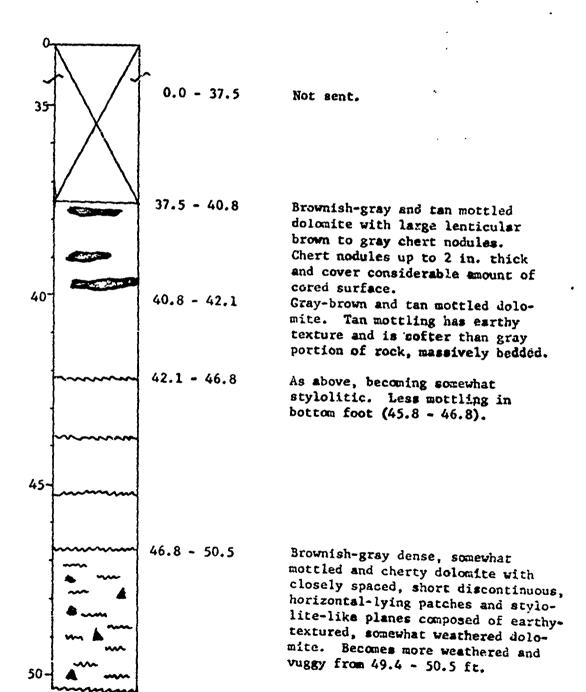
- (a)
  Based on examination of 300 or more particles in sieve sizes above.
- (b) Calculated from the grading and the composition of sizes shown.

  Material passing No. 22, 7.3 percent, was included with the No. 200 material in calculation.
- (c) Includes micas, carbonates, hornblende, garnet, and various other rocks and minerals.

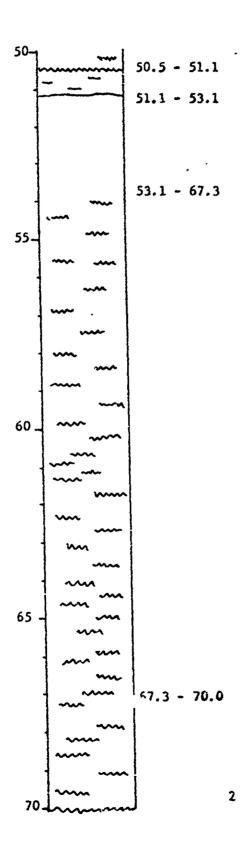
# Legend for Core Logs

	Dense limestone or dolomite.
	Limestone or dolomite with shale laminations or occasional shaly streaks.
	Shale or very shaly limestone.
	Limestone or dolomite containing vertical or diagonal fractures.
	Limestone or dolomite concaining stylolites.
"an un	Limestone or dolomite containing short stylolite-like patches or seams.
	Limestone or dolomite containing chert nodules or seams.

Gibbar Quarry No. 4 Red Rock, Missouri (STL-19 G-1)



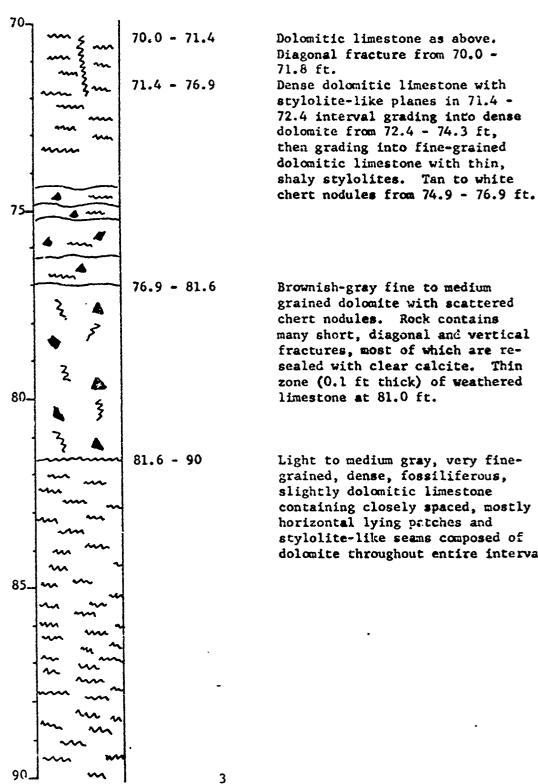
## Gibbar Quarry No. 4



Light brownish-gray silty dolomite, thin bedded. Brownish-gray, mottled dolomite. Mottled portion of rock stained, appears weathered, more porous than rest of rock.

Brownish-gray dolomite with short, discontinuous, horizontal lying patches and stylolite - like seams as in interval from 46.8 - 50.5 ft. - Iron staining along seams. Occasional small vugs in zone from 56.1 - 61.5 ft, some vugs filled with soft, white material, probably gypsum.

Grades into brownish-gray fine to medium-grained dolomite limestone with tan mottling in stylolite-like seams as above.



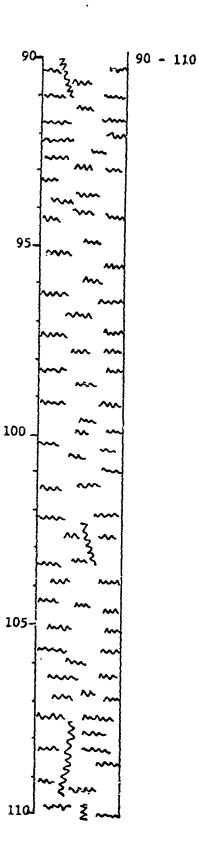
Dolomitic limestone as above. Diagonal fracture from 70.0 -71.8 ft. Dense dolomitic limestone with stylolite-like planes in 71.4 -72.4 interval grading into dense dolomite from 72.4 - 74.3 ft, then grading into fine-grained dolomitic limestone with thin,

Brownish-gray fine to medium grained dolomite with scattered chert nodules. Rock contains many short, diagonal and vertical fractures, most of which are resealed with clear calcite. Thin zone (0.1 ft thick) of weathered limestone at 81.0 ft.

Light to medium gray, very finegrained, dense, fossiliferous, slightly dolomitic limestone containing closely spaced, mostly horizontal lying patches and stylolite-like seams composed of dolomite throughout entire interval.

# Gibbar Quarry No. 4

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Light gray to medium-gray fine-grained limestone with patches and stylolite-like seams composed of dolomite as above, vertical fracture from 90 - 91 ft.

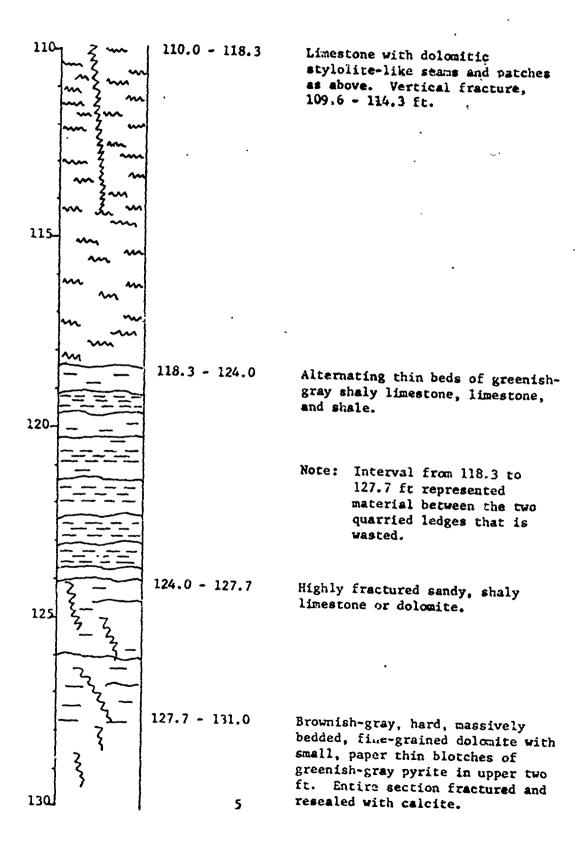
Vertical fracture from 102.1 - 103.3 ft.

Vertical fracture with 1-in. thick coarsely crystalline white calcite lining; 107.6 - 109.6 ft.

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# Gibbar Quarry No. 4

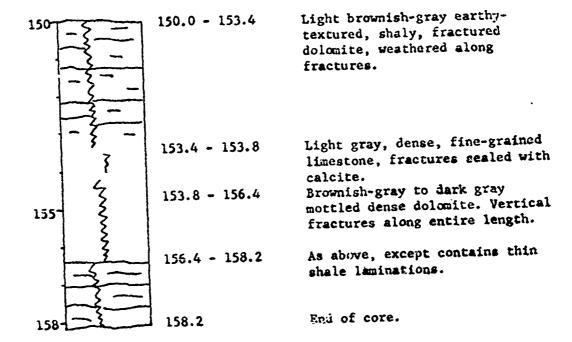
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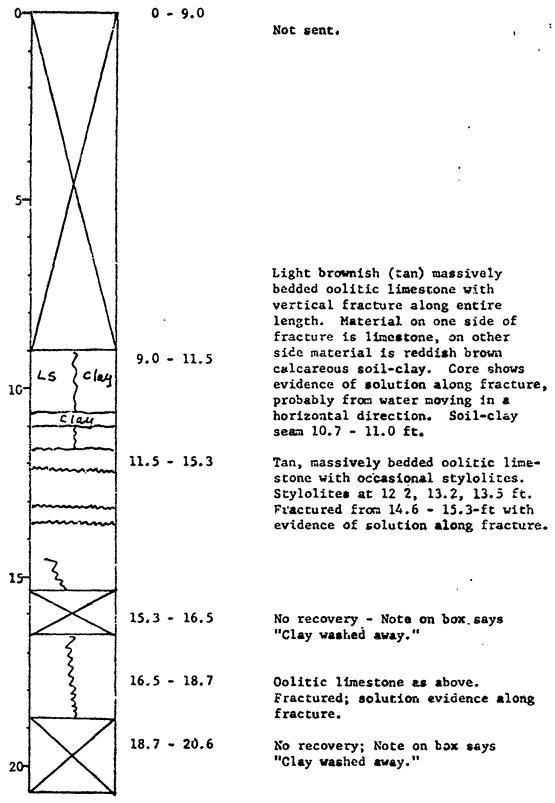
130-	3	130.0 - 131.0	As above
	Z 237 235 23	131.0 - 133.0	Hard, brownish-gray dolomite as above, fractures rescaled with calcite, scattered small rugs throughout interval.
	3	133.0 - 133.5	As above, except weathered red- dish-brown on fractures.
135-	1) 1 ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( )	133.5 - 134.5 134.5 - 136.1	Hard, brownish-gray shaly dolo- mite. Paper-thin shaly seams. Hard, brownish-gray dolomite. Vuggy, fractured, fractures partially resealed.
•	3 3	136.1 - 137.7	As above, except highly fractured.
	<b>\$</b>	137.7 - 139.6	Weathered and vuggy fractured dolomite, some fractures resealed with calcite.
140-	Andrew And	139.6 - 140.7	Brownish-gray earthy-textured dolomite, weathered on vertical fractures.
-	-3-	140.7 - 143.2	Brown and gray-brown mottled, shaly, vuggy, weathered dolomite. Very shaly 142.2 - 143.2 ft.
•		143.2 - 144.1	Brownish-gray and tan mottled, dense dolomite.
	{-{- 	144.1 - 145.6	Brownish-gray highly fractured shaly dolomite, weathered on fractures.
145-	-3-5-5-	145.6 - 146.0	Hard, brownish-gray vuggy dolomite.
		146.0 - 148.9	Hard, light gray to brownish-gray dense limestone with dolomitic patches and stylolite-like seams.
		148.9 - 149.4	As above, with shaly streaks.
150 _		149.4 - 150.0	Brownish-gray earthy-textured shaly dolomite.

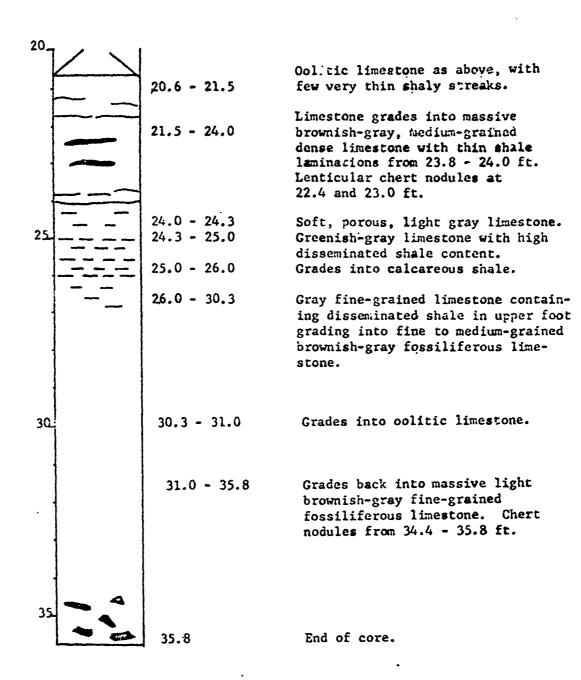
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West Lake Quarry No. 5
Hole WSG/1
(STL-19 G-2)

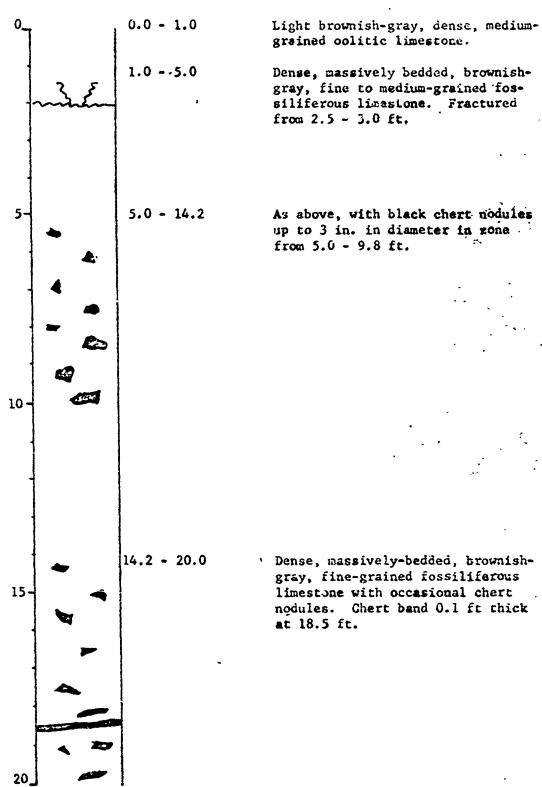




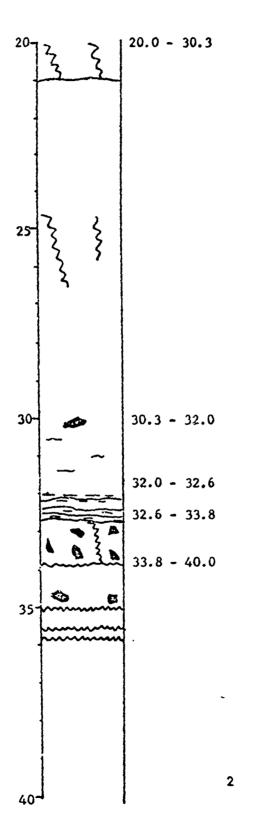
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West Lake Quarry No. 5
Little Rock Landing, Missouri
Hole WSG/lA
(STL-19 G-2)



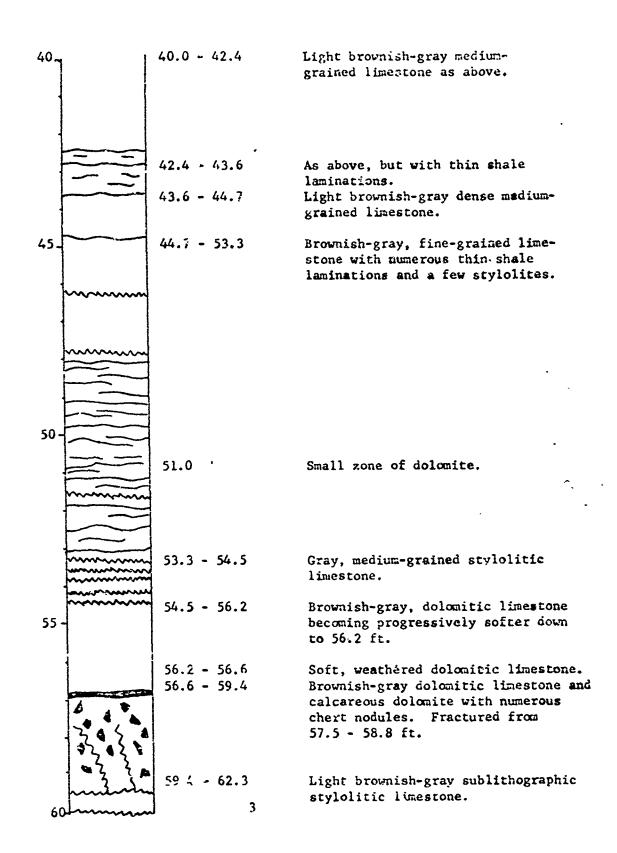
West Lake Quarry No. 5
Hole WSG/1A

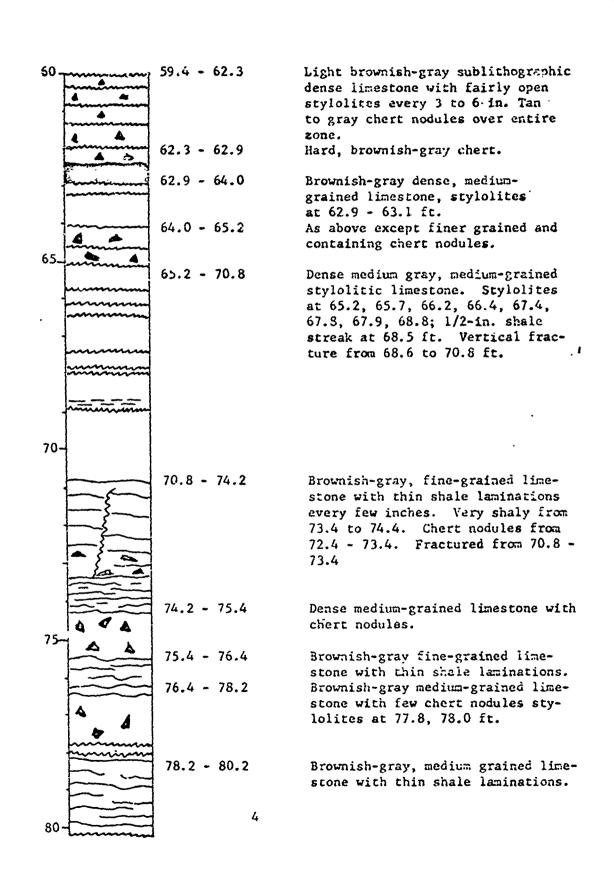


Dense, massively-bedded, fine to medium-grained, gray to brownish-gray, fossiliferous limestone. Fractures from 19.9 - 21.0 ft and 24.6 - 26.7 ft. Chert nodule at 30.2 ft.

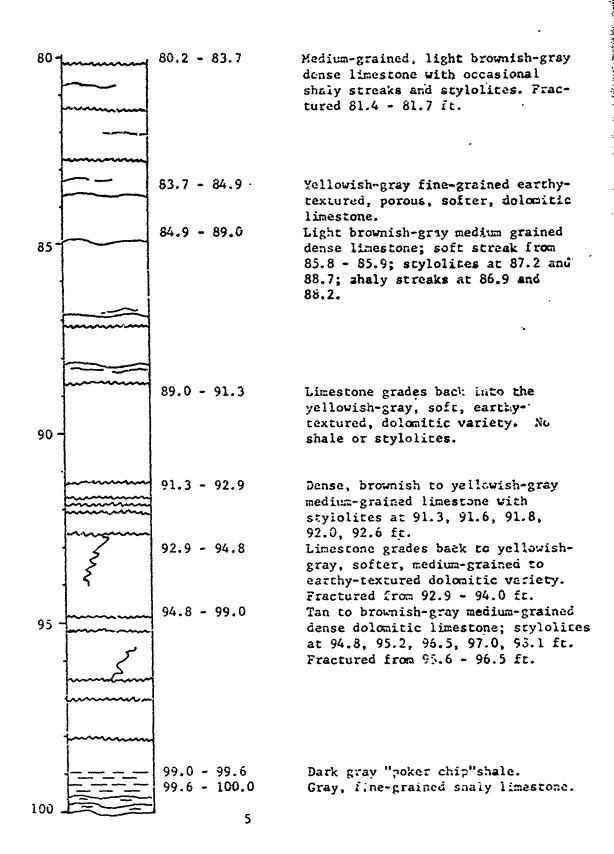
As above, except containing zones of disseminated shale.

Gray shaly limestone with numerous shale laminations.
Light gray fine-grained dense limestone with tan chert nodules.
Fractured, 32.6 - 33.8 ft.
Light brownish-gray, medium-grained dense limestone with stylolites at 35.1, 35.6, and 35.8 ft. Chert nodules at 34.9 ft. Limestone may be slightly porous.

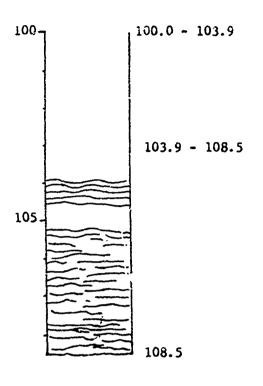




West Lake Quarry No. 5 Hole WSG/lA



West Lake Quarry No. 5 Hole WSG/lA



Light gray, hard, dense, very fine grained to sublithographic limestone and dolomitic limestone, massively bedded.

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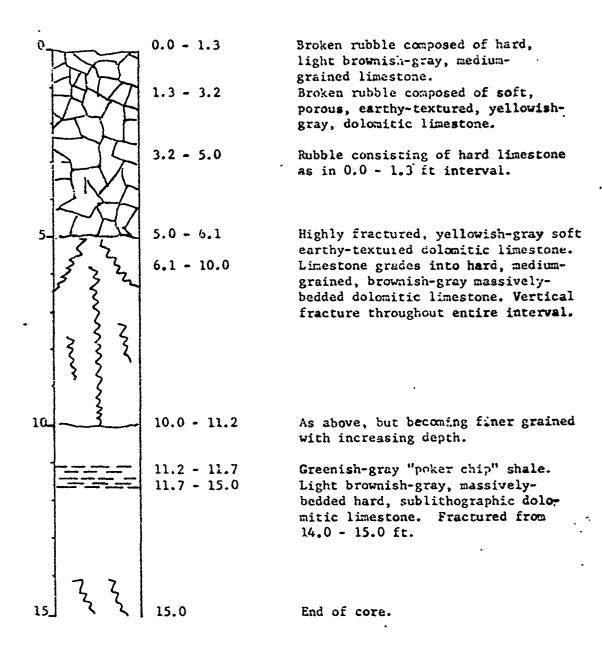
Light gray, hard, dense, sublithographic limestone and do ritic limestone with thin shale laminations. Shale at 103.9, 104.0, 104.1, 104.3, 104.6, 105.3, 105.4, and 105.8 and more numerous below.

End of core.

6

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West Lake Quarry No. 5
Hole WSG/IB
(STL-19 G-2)



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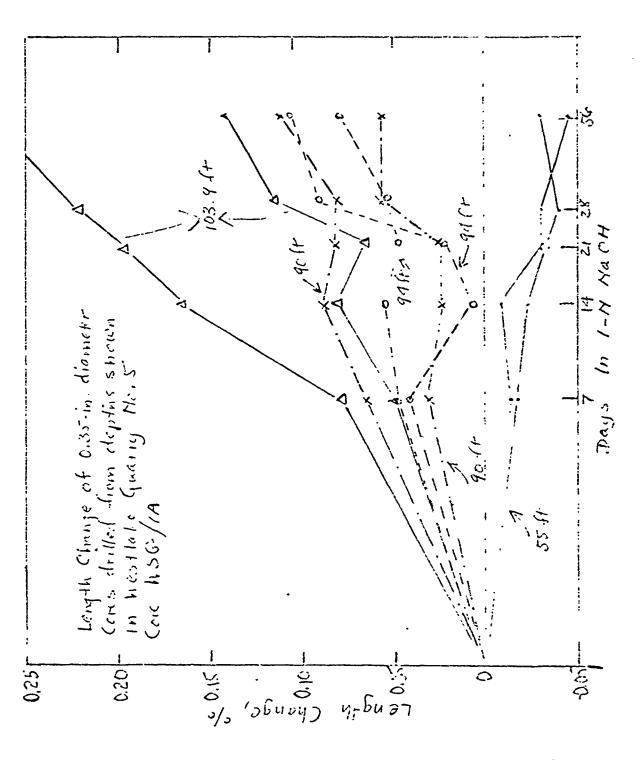


Figure 6

		<del></del> -													
STATE.		ouri	INC				RI	PRAP	. 1	STED BY	US VI	WES			
L AT.:	37			NG.	89		DAT	A SHEE	T D	AT E	May	1965			
LAB SYN	ABOL N	a: s:	TL-19	G-1				1	YPE C	J MATER.	AL: Kara				
LOCATION	N: Se	c ll	. R	2 E	T 3	5 N 1	Porry	County	214			<i>غا</i> لط <del>مال</del> ية الأخ 1- أماد (1			
Visco	GCATION: Sec 11, R 12 E, T 35 N, Perry County, Missouri, mair Red Rock.														
		· * ho:	- U 4		Dool	<u> </u>	P 2	2 7		• • •					
	30	u che	<u> </u>	ver	ROCK		non 3	s, Per	TVVI	TIE W	issouri	·	······		
									<del></del>						
SAMPLED	ay.	St. I	<u>ouis</u>	Dis	tric	t									
TESTED	FOR:	Caska	skia	Riv	er,	Illino	N, aic	avigat	lon	Improv	ement				
PROCESS	ING BEF	ORE T	ESTING												
									<del></del>	***************************************					
GEOLOGIC	AL FOR	MATION	440	AGE:											
CAACING	(CRD	C (03)	CLIM	Y- PAS:	unc):		T = :-	CT DC		- 1		T		h = 1 =	FINE
	(4.0	0.00	(000.	10 123.			1 1 5	ST RES	SULT:	يا	3-6	*   1 j - 3"	prwe	DOTO	166
SIEVE	3-6"	15-3"	3-160	-4-3-	FINE						. 1		Score	13.1 CG	700.
					<b>AGO.</b>			SURF DRY					2.69	2.6	1
6 IN.						ABSOMPT	ION, PER C	ENT (CAD	C 107	106):			10.4	1.7	
SIN.						CAGANIC	IMPURITE	ES, FIG. NO	(CRO	-C 121):		-			
4IN						SOFT PA	ATICLES,	PER CENT	(C20-	C 130):					
3IN.						PER CEN	T LIGHTE	R THAN SE	. CA	(CAD-C	(05:	1		<del>                                     </del>	
23 IN.						PER CEN	T FLAT A	NO ELONGA	TED (C	80-C 110,	26):	1	1	1	
2 IN.															
				-											
i g i No.				-		francisco de la companya de la comp									
1 IN.						UNIT WT., LB/CU FT (CRO-C 107: 167, 5167,0									
\$ 1 Na.						Toughness (CRD-C 132): 7/5* 7/7*			Ar .						
3 IN.						COAL AND LIGNITE, % (CRO-C 122);									
Ìm.				[		SPECIFIC	HEAT, BT	WLB/DEG.	F. (CA	D-C 124)		1	İ	1	i
NO 4						REACTIVE	NTIM YT	NoOH (C	RO-C	120): 34,	nM/L	7		i	
P=0.8										Ac,r	MA/L			T	
NG. 6						MORTAR-	MAIUNG	PROPERTIE	S (CR	) - C 116)	· · · · · · · · · · · · · · · · · · ·		^		
NC 30			<del> </del>			TYPE	CEM	ENT. RATIO	)	DAYS.			DAYS,_		٧.
NO 50											(CAD-C				
			<u> </u>	-			ROCK				ACROSS	<del></del>	1	AVERA	
NO. 160							HOCK .	1177		MALLEL	ACHOSS			AALHA	
<b>43.200</b>	Ĺ			<b></b>											
- 200				<u> </u>					<u> </u>			1			
f.M(0)			l			ــــا ا			_1_						
(a) CAD-	C 105	(b) CA	D-C	04		MORTA	A:								
	B45	34515.5			1000			FINE AG	CREGAT	٤		COARSE	AGGH	GATE	
MGRYAR -	DAM FX	r~~510	m ai k	70 , To	CHO.	C 123J	3 MQ.	6 MO.	9 MC	). 12 MC	3 140	6 MO	. 0	MO.	2 MG
LOW-A	LA. CEN	ENT:		70 No.	O EQUI	VALENT:				1		7	<del> </del> -		
	ALM, CEA					VALENT:		1		1		1			
SOUNDNE								نــــــــــــــــــــــــــــــــــــــ				1 7 8 1	ندا بنو ر	- ( 5   ,	0 - CW
	AGG. S							7 30 0	<del></del>	<del></del>		<del>-  </del>	177		- C W
PINE	AGG.	FL-19	<del>-s-1</del>			COARSE A		L-19 G	<u>- I</u>	<del></del>	DFE 300	1 71	-		
FINE .	AGG.					COARSE A	GG:				DF E 300		i		
PETROGR	APHIC	DATA (	CRD-C	(27):											
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perpendicular to the structural weakness and the number to the structural height of the number to the structural height of the humber to the structural height of the blow parallel to the structural weakness of the numble.

Corps of Engineers, USAE Riprap Data Sheet Concrete Division
P. O. Drawer 2131
Jackson, Mississippi
Project Date

Project Kaskaskia River, Illinois, Navigation Improvement

May 1965

A A A COLOR AL C'ATUME A TOR CHASTON CARACTERICA ASSESSED 
STL-19 G-1 (5-in. Core) Gibbar Quarry No. 4

# Toughness. (CRD-C 132):

THE SECTION OF THE SE

		Height of Blo	ow at Failure, o	cra	
Test No.	Perpendicular of Structural		Parallel to Plane of Structural Weakness		
	Limestone	Dolomite	Limestone		Dolomite
1	6	4	5		9
2	8	6	5		4
3	6	10	6		8
Avg	7	7	5		. 7

## Freezing and Thawing in Water and Alcohol (CRD-C 144):

Type of	Specimen	Original OD wt.	Larger 25 % c		Wt Loss During	Cycles
Stone	No.	<u> </u>	_8	7.	Test, 7	Completed
Limestone	1	5710	0	0.0	100	14
	2	5567	5552	99.7	0.3	20
	3	5233	4917	94.0	6.0	20
	Avg				35.4	
Dolomite	1	5403	3728	69.0	31.0	20
	2	5598	5465	97.6 .	2.4	20
	3	3229	3048	94.4	5.6	20
	Avg				12.7	

Final OD wt.

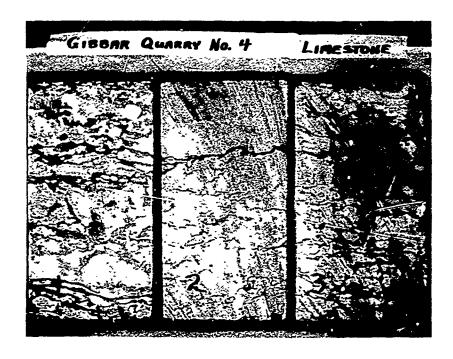
#### Riprap Data Sheet

1. Samples were taken from the intervals shown below for ripraptests:

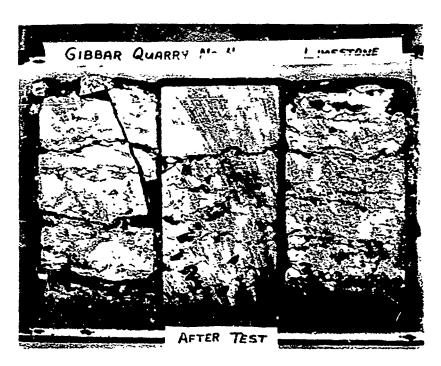
ft	Rock Type
40.3	Dolomita
55.6	
60.6	
ö9.0	
80.3	
83.5	Linestone
87.3	
96.8	
105.7	
118.0	
	40.3 55.6 60.6 69.0 80.3 83.5 87.3 96.8 105.7

- 2. After 20 cycles of freezing and thawing according to CRD-C 144, the following observations were made:
- a. <u>Limestone</u>: Piece 1 had fragmented into pieces weighing less than 25 percent of the original weight. Piece 2 had 'ost minor amounts of material; Piece 3 slightly more; both were fragile.

<u>Dolomite</u>: The chert band in Piece 1 was disrupted; its weight c .ned with the weight of the otherwise unaffected end of the slab was 31 percent of the original. Losses from the other two pieces were trivial.

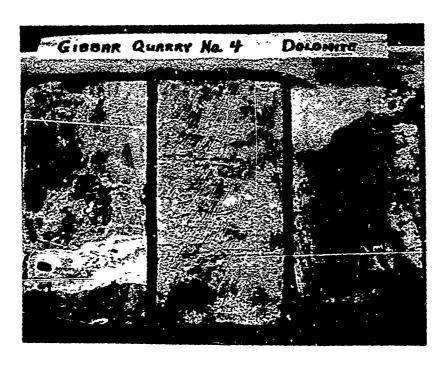


a. Before test

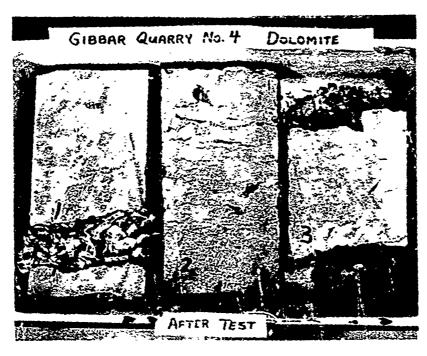


b. After test

Fig. 1A. Gibbar Quarry stone tested for freezing and thawing in an 0.5 percent solution of water and alcohol.



a. Before test



b. After test

Fig. 1B. Gibbar Quarry stone tested for freezing and thawing in an 0.5 percent solution of water and alcohol.

STATE Missouri MADEA NO. RIPRAY							
LAT. 38 LONG. 90 DATA SHEET JOATE							
LAS. SYMBOL NO.: STL-19 G-2 TYPE OF MATERIA							
LOCATION: Sec 19. R 9 S, T 38 N, Ste. Genevieve County, M	<u>issour:</u>	<u>. 25 %:</u>	<u> </u>				
Rock, Missouri.							
PACOLCER: West Lake Quarry and Materials Co., Box 206, T	auchin	<u>,₹~~*,</u>	<u> 3 - 1 5 45 1 </u>				
Missouri.							
SAMPLED BY: St. Louis District							
	rested Foa: Kaskaskia River, Illinois, Navigation Improvement						
PROCESSING BEFORE TESTING:							
	<del></del>						
GFOLOGICAL FORMATION AND AGE: Ste. Genevieve limestone and St	. Louis	<u>lines</u>	cope, Mera-				
mec group, Middle Mississippian Age.	<u> </u>	<u>inesto</u>	<u> </u>				
GRADING (CRD-C 103)(CUM. 70 PASSING) TEST RESULTS	ารอ เรอ	-Sha-Di	1 00- FINE				
SIEVE 3-6" 11-3" 3-15" 4-3" AGG OULK SP. GA, SAT SURF DAY (CRD-C 107,108):	2.66	(7 677	5212.65				
6 IN. ABSORPTION, PER CENT (CRD-C 107, 108).			2 0.2!				
SIN.   CRGANIC IMPURITIES, FIG. NO (CRD-C 121)							
4IN. SOFT PARTICLES, PEH CENT (CRD-C 130)	i	!					
3 IN. PER CENT LIGHTER THAN SP.CR(CAD-C -	29)1	1					
22 IN. PER CENT FLAT AND ELONGATED (CRD-C 119,	20):	!					
2 IN. WEIGHTED AV. % LOSS, S CYC MSSO4 (C) 1-1, 4		·C ::5)	· · · · · · · · · · · · · · · · · · ·				
1 1 1N. ABRASION LOSS (L. A.), 70, (CRD-C 117)1			01 2/ 0-				
1 IN. UNIT WT., LB/CU FT (CRD-C 107):			7.3355.1				
21N.   Toughness (CDD-C 132):	7:4:		/5= 9 / ×				
1 10.   COAL AND LIGHTE, % (CRD-C 122):		- i :					
SPECIFIC HEAT, BTU/LB/DEG. F. (CAD-C 124):	<del></del>	1 1					
NO.4 REACTIVITY WITH NOOH (CRD-C 128) Sc,		<del></del>					
<del> </del>	M/L"						
NO 16   MORTAR-MAKING PROPERTIES (CAD-C 1.6)			<del></del>				
NO 30 TYPE CEMENT, RATIO DAYS,	ጚ_	0	AYS,%				
NO 50 LINEAR THERMAL EXPANSION XIO YDEG. F.							
NO 100 ROCK TYPE   PARALLEL			AVERAGE '				
NO.2GO	 i	i	<del></del>				
- 200(**)		1					
F.M.(b)		<del>                                     </del>	<del>- [</del>				
(a) CRD-C 105 (b) CRD-C 104 MORTAR:	L	<del></del>	<del>i</del>				
FINE AGGREGATE		COARSE A	GGREGATE				
MORTAR-BAR EXPANSION AT 100F, % (CRD-C 123)	), 3 MO.		10 MO 12 MO				
LOW-ALK. CEMENT: % No 20 EQUIVALENT:			1 1				
M.GH-ALK.CEMENT: 70 No 20 ECUIVALENT:							
SOUNDNESS IN CONCRETE (CRD-C 40, 114):	_1	FLT	, HW-CD . HD-CM				
FINE AGG. COARSE AGG:	DFE 100	<del></del>	1 ;				
		<del>-i</del>	<del> </del>				
FINE AGG. COARSE AGG: OFE 300							

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REMARKS: \* The number to the left is the height of the blow at failure in c., perpendicular to the structural weakness and the number to the right is the height of the blow parallel to the structural weakness of the sample.

WES FORM 726 JAN. 1951

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Corps of Engineers, USAE

Riprap Data Sheet

Concrete Division P. O. Drawer 2131 Jackson, Mississippi

Project

Kaskaskia River, Illinois, Navigation Improvement

Date

May 1965

STL-19 G-2 (6-in. Core) West Lake Quarry No. 5

## Toughness (CRD-C 132):

Height of Blow at Failure, cm Parallel to Plane of Perpendicular to Plane Structural Weakness of Structural Weakness Test No. Soft Soft Dense Shaly Weathered Oolitic Dense Shaly Weathered Oolitic 8 7 3 8 5 7 4 7 1 7 4 5 6 4 8 2 8 12 6 5 9 3 9 5 3 7 11 8 7 5 7 7 10 Avg

### Freezing and Thawing in Water and Alcohol (CRD-C 144):

Final OD wt. of Fragments Larger Than Original 25 % of Wt Loss During Type of OD wt. Original wt. Cycles Specimen Stone No. Test, % Completed Dense 1 99.6 0.4 20 5133 5113 2 Limestone 5035 4745 94.2 5.8 20 3 4443 3806 85.7 14.3 14 Avg 6.8 Shaly 1 5122 5081 99.2 8.0 20 2 Limestone 5422 4201 77.5 22.5 17 3 5124 4935 96.3 . 3.7 20 9.0 Avg Soft 1 4576 4465 97.6 2.4 20 2 Weathered 4265 4238 99.4 0.6 20 3 Limestone 4504 4267 94.7 5.3 20 Avg 2.8 Oolitic 1 4419 99.7 20 4430 0.3 2 5325 5315 99.8 0.2 20 3 4563 4553 99.8 0.2 20 0.2 Avg

### Riprap Data Sheat

1. Samples were taken from the intervals and holes shown below for riprap tests:

Oolitic Limestone		Shaly Limestone				
Depth, ft	Hole	Depth, ft	Hole			
11.5 to 12.2	WSG-1	42.3 to 43.3	WSG-1A			
12.2 to 13.1	WSG-1	45.7 to 46.3	WSG-1A			
17.7 to 18.7	WSG-1	48.3 to 49.3	WSG-1A			
20.6 to 21.3	WSG-1	75.4 to 76.2	WSG-1A			
30.3 to 31.0	WSG-1	79.1 to 80.2	WSG-1A			

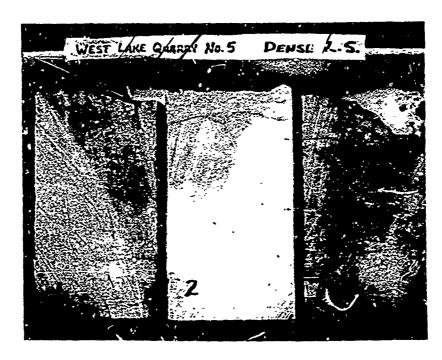
Soft Weathered

Limestone		Dense Limestone			
Depth, ft	Hole	Depth, ft	liste		
84.1 to 84.8	WSG-1A	6.5 to \$.0	WSG-1B		
89.2 to 89.7	WSG-1A	8.4 to 9.2	WSG-1A		
89.7 to 90.4	WSG-1A	23.0 to 24.2	WSG-1A		
90.4 to 91.1	WSG-1A	32.8 to 34.0	WSG-1		
		64.0 to 65.0	WSG-la		

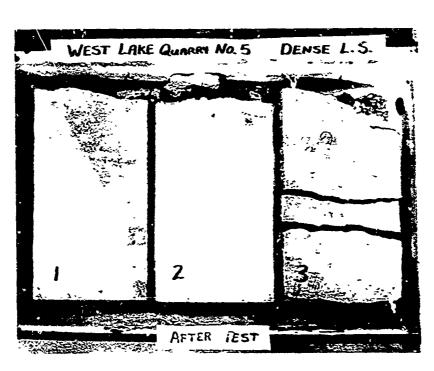
- 2. After 20 cycles of freezing and thawing according to CRD-C 144 the following observations were made:
- a. <u>Dense limestone</u>: Pieces 1 and 2 pratically unaffected.

  Piece 3 broke into three fragments along an old crack.
- b. Shaly limestone: No effect on Piece 1. Fieces 2 and 3 broke into two and three fragments; rock still strong.
- c. <u>Soft weathered limestone</u>: No effect on Pieces 1 and 2.

  Some surface spalling around old cracks in Piece 3. Rock still strong.
- d. <u>Oolitic limestone</u>: The test had practically no effect on the three pieces of rock.

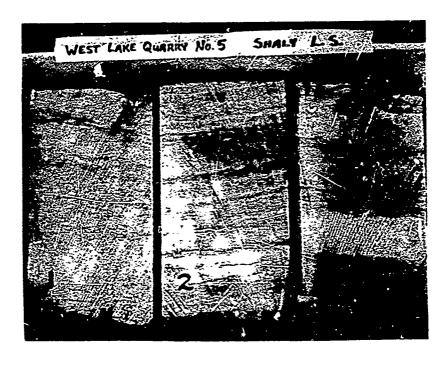


a. Before test

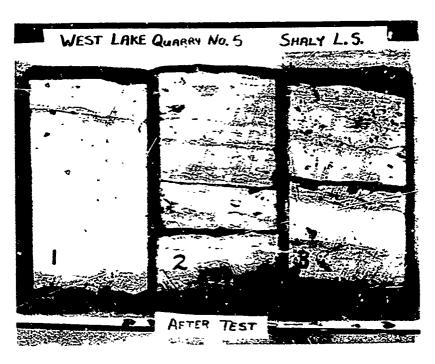


b. After test

Fig. 2A. West Lake Quarry No. 5 stone tested for freezing and thawing in an 0.5 percent solution of water and alcohol.

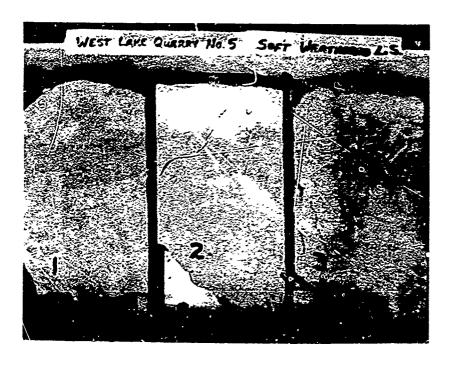


a. Before test

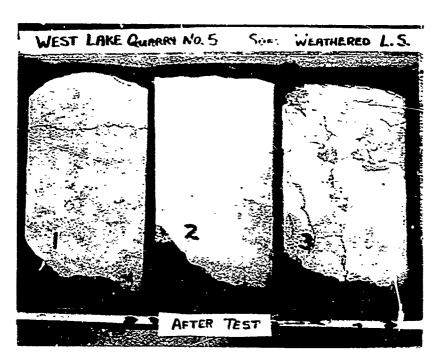


b. After test

Fig. 2B. West Lake Quarry No. 5 stone tested for freezing and thawing in an 0.5 percent solution of water and alcohol.



a. Before test

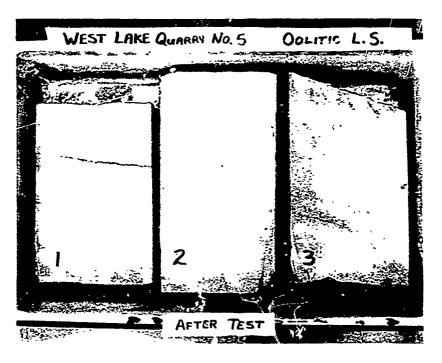


b. After test

Fig. 2C. West Lake Quarry No. 5 stone tested for freezing and thawing in an 0.5 percent solution of water and alcohol.



a. Before test



b. After test

Fig. 2D. West Lake Quarry No. 5 stone tested for freezing and thawing in an 0.5 percent solution of water and alcohol.

STATE: LAT.:	Illi	nois	IND	EX NO:			RI	PRAP	7	TESTEC	BA: 1.	94717	<u> </u>			
LAT.:	38		LON	ıc.i 9	0		DATA	SHEE	r	DATE:	ŀ	ay 19	65			
LAG. SYM	BOL N	0: 57	TL-19	G-3	(A)	and G								k		
LOCATION	ı: Se	c 16	, R 9	W.	Ť 5	S, Rat	ndolph	County	, ·	Illi	nois,	1/2-	nile	N of		
Prair	ie d	u Roc	her.	T11	inoi	9	<u></u>									
							Roche	r, Ill:	no	ic					·····	
						10.00	100110			<u></u>						
SAMPLED	BY:	St. I	OUT	n:e	tric	+										
TESTED	FCR:	Kask	skia	Riv	er.	T111n	ole N	visat	an	Tmn	<b>*</b> 0110	on!				
PROCESSI	NG BE	ORE T	ESTING	:	. Z. A., L		Y & W	A Y. A. La La La	VIL		AUYCI	· <u>· · · · · · · · · · · · · · · · · · </u>				
							<del></del>									
		-						********								$\neg \neg$
CEOLOGIC	AL FO	MATION	AND	AGE:												
													C-3	1	C-3B	
GRADING	(CRD	- G 103	(CUM.	70 PAS	SING):	1	TE	ST RES	UI T	5			ense	Simily	Dense	FINE
					FINE	1	<u></u>			ت		3-6	Lin	esto	he	AGG.
SIEVE	3-6"	11-3"	2-15	#4- 2"			GR , SAT .	SURF DRY	CRD	-C 107	7,108):		2.67			;
6IN.								ENT (CRD-					0.4			
SIN.						<del> </del>		S, FIG. NO				1	10.4	<u> </u>		
4 IN.						<del></del>		PER CENT				<del></del>	<del>   </del>			
3 IN.		<del> </del>		<del> </del>				THAN SP				));	<del> </del>			<del>  </del>
2 IN.				<del> </del>	<del></del>	<del></del>		VD ELONGA					<del>  </del>		<del> </del>	<del>  </del>
2 IN.					<b></b>			oss, 5 CYC.					C 115)			<del>                                     </del>
I∮IN.			<del> </del>	├				A ),%. (				TICKU-		05.0	00	
I IN.			<del> </del>	├─	<del> </del>	<del></del> -		T (CRD-C			<del></del>		32.8			
3 IN.		├	<del> </del> -	<del> </del> -									165.3			
3 IN.		<del></del>		├			Toughness (CRD-C 132); 7/7*: 7/8# 8/7*						-			
<del></del>	<del> </del>		<del> </del>	<del>├</del> -	ļ	COAL AND LIGNITE, % (CRD-C 122):						<del>  </del>				
IN.			<del> </del>	<del> </del> -		<del></del>		U/LB/DEG.							ļ	4
NO. 4				<b>├</b>	ļ	PEACTIV	ITY WITH	NaOH (C	RD-C	5 128)	<del></del>	<del></del>	<b> </b>		<u> </u>	<b> </b> -
NO. 8	<u> </u>		<del> </del>	<b>├</b>	<u> </u>	<u> </u>					Renn	<u> </u>	لــــــــــــــــــــــــــــــــــــــ	L	L	
NQ.16	ļ	<u> </u>	ļ	<u> </u>		4		PROPERTIE	_		-					
NO 30		<u> </u>		<u> </u>		"YPE_	СЕМЕ	NT, RATIO		DA	YS,	~ <u>~</u> ,		DAYS,		<u> </u>
NO 50		ļ	<u> </u>			LINEAR	THERMAL	EXPANSI	K NC	(10 90	EG. F. (	CRD-C 12	?5,126) <sup>.</sup>			
NO. 100	<u> </u>		<u> </u>			l i	ROCK	TYPE		PARAL	LEL	ACROSS	Of	4	AVER	AGE
NO.200	<u> </u>	<u> </u>	<u> </u>	<u> </u>	<u> </u>	J L										i
- 200 <sup>(*)</sup>	<u>!</u>	<u> </u>	L	·		J L										
F.M. <sup>(b)</sup>	<u> </u>															
(e) CRD-	C 105	(P) C	Ru •			MORTA	R:									
MORTAR-	DAD E	VDANICIO			CDD	-6 (22):		FINE AG	PEG	ATE			COARSE	AGGR	GATE	
	- BAAL E	APANSIU		, 9;	LCHU	-C 123):	3 MO.	6 MO.	9 1	MO.	12 MG.	3 MO.	6 MO	10	MO.	12 MO.
LOW-	ALK, CEI	MENT:		% No.	O E0U	IVALENT:						T				
HIGH-	ALK.CE	MENT:		% No:	O EQU	WALENT:							<b> </b>	_		
SOUNDNE	ESS IN	CONCR	ETE (C	RD-C	40, 114	1):	·	<u></u>				<u> </u>	FET	н₩	-co!	HD-CW
FINE	AGG.					COARSE A	(GG:					DFE 300	<del>                                     </del>	_		
FINE	AGG.					COARSE A	IGG:					DFE 300	<del>                                     </del>	_		<del></del>
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Corps of Engineers, USAE

Riprap Data Sheet

Concrete Division P. O. Drawer 2131 Jackson, Mississippi

Project

Kaskaskia River, Illinois, Navigation Improvement

Date

Hay 1965

STL-19 G-3(A) Upper 13-ft and middle 10-ft ledges, Stotz Quarry

#### Toughness (CRD-C 132):

Height of Blow at Failure, cm Paraliel to Plane of Perpendicular to Plane Test No. of Structural Weakness Structural Weakness Dense Dense Shaly Shaly Limestone Limestone Limestone Limestone ì 5 7 6 ъ 2 8 8 9 10 3 7 6 7 6 7 7 8 Avg

#### Freezing and Thawing in Water and Alcohol (CRD-C 144):

Final OD wt. of Fragments Larger Than Original 25 % of Wt Loss Type of Specimen OD wt. Original wt. During Cycles Stone No. \_%\_\_ Test, ኧ Completed 1 4006 3969 99.1 0.9 20 Dense Limestone 2 4520 4509 99.7 0.3 20 3 4584 98.6 1.4 20 4521 Avg 0.9 Shaly 1 4274 3658 85.6 14.4 20 Limestone 2 4232 4178 98.7 . 1.3 20 3 4425 4400 20 99.4 0.6 Avg 7.8

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Corps of Engineers, USAE Riprap Data Sheet Concrete Division
P. O. Drawer 2131
Jackson, Mississippi

Project Date
Kaskaskia River, Illinois, Navigation Improvement Hay 1965

STL-19 G-3(3) Lower 14-ft Ledge, Stotz Quarry

Mind of the state 
## Toughness (CRD-C 132):

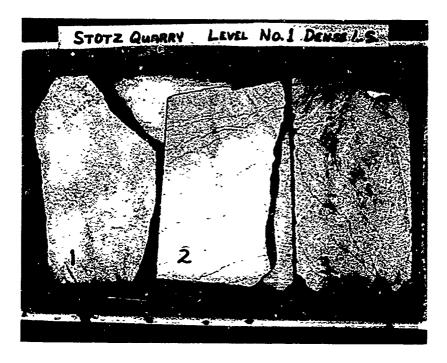
-	Height of Blow at Failure, cm						
	Perpendicular to Plane	Paraliel to Plane of					
Test No.	of Structural Weakness	Structural Heakness					
_	,	۵					
1	b	8					
2	9	7					
3	9	6					
Avg	8	7					

# Freezing and Thawing in Water and Alcohol (CRD-C 144):

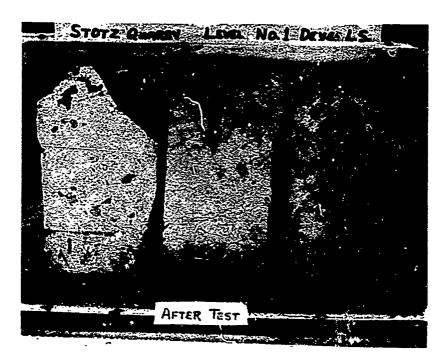
Final OD wt. of Fragments Larger Than Original 25 % of Wt Loss OD wt. Cycles Type of Specimen. Original wt. During Stone No. Test, % Completed 4301 4203 99.6 0.4 20 ı Dense 99.6 5248 5228 0.4 20 2 Limestone 20 4487 4463 99.5 0.5 3 0.4 Avg

### Riprap Data Sheet

- 1. After 20 cycles of freezing and thawing according to CRD-C 144 the following observations were made:
  - a. STL-19 G-3(A).
- (1) <u>Dense limestone</u>: Very light surface spa'ling and and fragmentation along stylolites of all 3 pieces. Piece 3 developed open crack and was becoming fragile.
- (2) <u>Shaly limestone</u>: This rock was much like the dense rock once it was sawed. Light surface spalling and fragmentation along cracks and stylolites during test. Piece 1 lost two large fragments along old cracks. Pieces 2 and 3 were becoming fragile.
  - b. STL-19 G-3(B).
- (1) Dense limestone: Light surface spalling and fragmentation along stylolites. Piece 3 developed a crack.
- c. <u>Both ledges</u>. Visible effects of test more pronounced in rock from upper ledge (3A). Some tendency for rock to develop cracks perpendicular to bedding direction, thus becoming fragile.

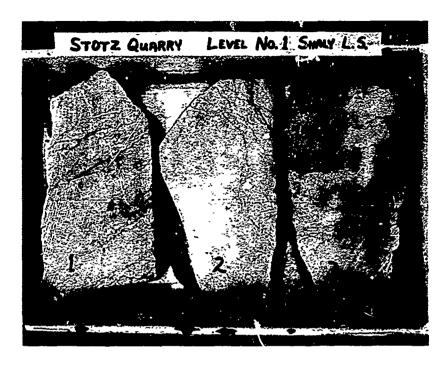


a. Before test



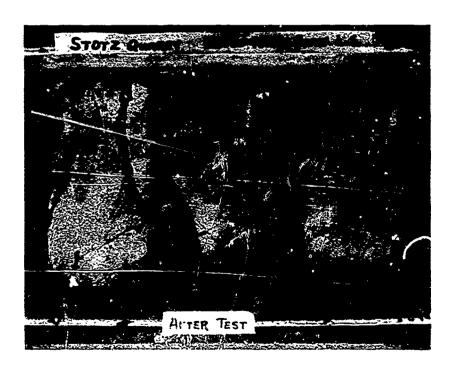
b. After test

Fig. 3A. Stotz Quarry stone from ledges 1 and 2 tested for freezing and thawing in an 0.5 percent solution of water and alcohol.



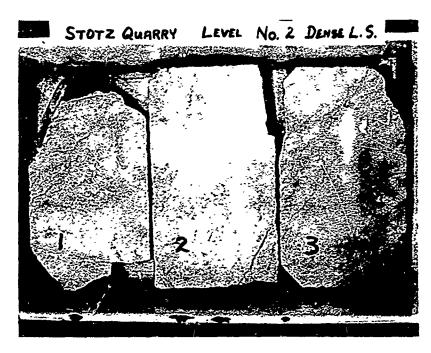
a. Before test

AND THE REPORTED THE CONTROL OF THE



b. After test

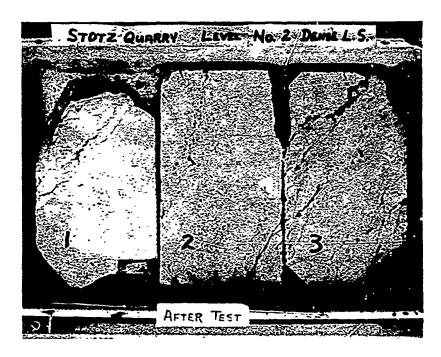
Fig. 3B. Stotz Cuarry stome from ledges 1 and 2 tested for freezing and thawing in am 0.5 percent solution of water and alcohol.



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A THE THE PROPERTY OF THE PROP

a. Before test



b. After test

Fig. 3C. Stotz Quarry stone from ledge 3 tested for freezing and thawing in an 0.5 percent solution of water and alcohol.

CTATE:		<u> </u>	(min)	- V - K- C		<del></del>		~~~	1		nv:					
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						4(3).								<u></u>		
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SAMPLED	BY:	St.	Louis	s_Dis	itri	: =										
				a_Ri	er.	Illing	ois. I	lavinat	ion	Ing	rove	ment				
PROCESSI	NG BEF	ORE T	ESTING													
CEOLOGIC	AL FOR	MATION	AND	AGE:	Sale	em Lime	stone	. Mera	mec	gra	up.	Middle	a_Mis:	عين	يجون	30
Age	<u> </u>					,	<del></del>			-,-		[G- 5/	\G-38	<u>G-30</u>	) G-3	<u>06-35</u>
GRADING	(CRD-	- C 103)	(CUM.	70 PAS	SING):		TE	ST RES	SULT	s ]		ladga	2	-201 -11:5	7 (* 3 V 11 (2)	_lcc.ge
SIEVE	3-6"	15-3"	3-16"	<b>*4-3</b> *	FINE	Ŀ						1:1	12	i.S	ris	1 =
		•	-		AGG.	BULK SP.							12.64			
6 IN.							BSORPTION, PER CENT (CRD-C 107, 108): 1.6 0.7 1.5 1.1 10.7						10.7			
51N.						<del></del>	RGANIC IMPURITIES, FIG. NO (CRD-C 121)						<u>-</u>			
4 IN.							SOFT PARTICLES, PER CENT (CAD-C 130):									
31N.					<u></u>		ER CENT LIGHTER THAN SP.GR(CRD-C 129)1									
SĮIN.				<u></u>	<u> </u>	PER CENT	PER CENT FLAT AND ELONGATED (CRD-C 119,120):									
2 IN.						WEIGHTED AV. % LOSS, 5 CYC. MgSO4 ((C) 1/2-1", #4-1/2) (CRD-C 115)										
I Į IN.			Ĺ			ABRASION LOSS (L. A.), %, (CRD-C 117): 26.694.7 29. 928.452.0  UNIT WT., LB/CU FT (CRD-C 107): 152.6164.5162.6162.6763.7										
I IN.						UNIT WT.	, LB/CU	FT (CRD-	c 107)	):		152.	6164.5	162.	6:62	£ 7 67. 7
≩IN.						Tough	ness	CRD-C	132	<b>)</b> :			*9/5~			
₹IN.				1		COAL AND	LIGNITE	,% (CRD	-C 12	2):		1	-		-1-	-
ξiN.					[	SPECIFIC	HEAT, BT	WLB/DEG	. F. (CF	40-C	124):					
NO 4		i				REACTIVE	TY WITH	NoOH (	AD-C	128)	Se,m	M/L	T			
NO.8						1					Rc,m	WL:				i
NOIS			i		1	MORTAR-	MAKING	PROPERTIE	5 (CR	D-C	116)					
NO 30		1				TYPE	CEM	ENT, RATI	۰	DA	YS,	<b></b> ~,		DAYS	,	
NO.50			i		1			EXPANS								
NO. 100						1	ROCK	TYPE	1	PARAL	LEL	ACROSS	1 0	7	AVE	RAGE
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(e) CRD-		(b) Ci	AD-C	104	<del></del>	MORTAL	R:					<del></del>				
						1		FINE AG	GREGA	TE		1	COARSE	AGG	REGATE	·
MORTAR-	BAR E	KPANSIC	N AT I	00F, 7	o (CRD	-C 123):	3 MO.	6 MO.	9 M		12 MO.	3 MO.	. 6 MO	<u> </u>	MO.	12 MO.
I OW-	ALK. CE	MENT:		% No.	0. FOI	IVALENT:	3 11.0,		-	<u>-</u>		1	+	1		
<b>}</b>	ALK.CE					IVALENT:		<del> </del>	├			+	+	+-		
			ETE C					<u> </u>	ـــــ				FAT		W ~ C D	HD-CW
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FINE						COARSE A						DFE 300				<del> </del>
FINE			<u></u>			COARSE A	<u>~~,</u>				<u></u>	OF€ 300				l
PETROGR	WHIC	UATA	CRD-	L (27):												

PREMARKS: \* The number to the left is the height of the blow at failure in cm, perpendicular to the structural weakness and the number to the right is the height of the blow parallel to the structural weakness of the samples.

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P. O. Drawer 2131
Jackson, Mississippi
Project
Kaskaskia River, Illinois, Navigation Improvement May 1965

STL-19 G-4(A) Ledge No. 1, Bussen Quarry

## Toughness (CRD-C 132):

-	Height of Blo	ow at Failure, cm
Test No.	Perpendicular to Plane of Structural Weakness	Parallel to Plane of Structural Weskness
1	6	3
2	8	10
3	8	9
Avg	7	9

# Freezing and Thawing in Water and Alcohol (CRD-C 144):

Type of	Specimen	Original OD wt.	of Fra Larger 25 % c		Wt Loss During	Cycles
Stone	No.	<u> </u>	_8	7.	Test, 7	Completed
Dense	1	3272	3261	99.7	0.3	20
Limestone	2	4038	4052	99.1	0.9	20
	3	5313	5308	99.9	0.1	20
	Avg				0.4	

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# STL-19 G-4(B) Ledge No. 2, Bussen Quarry

### Touchness (CRD-C 132):

	Height of Blo	Height of Blow at Foilure, cm					
	Perpendicular to Plane	Paraller to Plane of					
Test No.	of Structural Weakness	Structural Weakness					
1	9	9					
2	8	11					
3	9	7					
Avg	9	9					

#### Freezing and Thawing in Water and Alcohol (C:D-C 144):

Type of	Original f Specimen OD wt.		of Fra Large: 25 4 c		We Loss Daring	Oveles
Stone	No.	<u>8</u>	_8		Test, 7	<u> Co : ceë</u>
Dense	1	4467	4453	99.7	0.3	20
Limestone	2	4687	4677	99.3	0.2	20
	3	4482	4475	99.8	0.2	20
	Avg				0.2	

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Ruskaskia River, Illinois, Navigation Improvement May 1965

STL-19 G-4 (C) Ledge No. 3. Buster Quarry

### Toughness (CRD-C 132):

	Height of Blow at Pailure, cm								
Test No.	Perpendicula of Structura		Paralle, cy Plus (M) Schlaturul Werkhees						
	Shaly Limestone	Dense Limestone	Shaly Linestone	Dense Limestone					
1	7	\$	7	8					
2	7	10	8	7					
3	7	10	6	8					
Avg	7	9	7	8					

# Freezing and Thawing in Water and Alcohol (CO-C 14 ):

Type of	Specimen	Original	oi fra Larger 25 % s		Wo Loss During	Cycles
Stone	No.	<u></u>	_ <u>&amp;</u>	-7	Test, 7.	<u>Chinetes</u>
Shaly	1	4897	4785	97.7	2.3	20
Limestone	2	4853	4810	99.1	0.9	20
	3	4319	4269	93.8	1.2	20
	Avg				1.5	
Dense	i	4766	4729	99.2	0.8	20
Limestone	2	4492	4484	99.8	. 9.2	20
	3	4022	3971	98.7	1.3	20
	Avg				0.8	

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Corps of Engineers, USAR	• • • • • • • • • • • • • • • • • • • •	Concrete Division  J. H. J. V. T. 171  Jackson, R. Glandppi

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May 1965

i. . . . . .

STL-19 G-4(D), Ledge No. 4, Bussen Quarry

## Touchness (CRD-C 132):

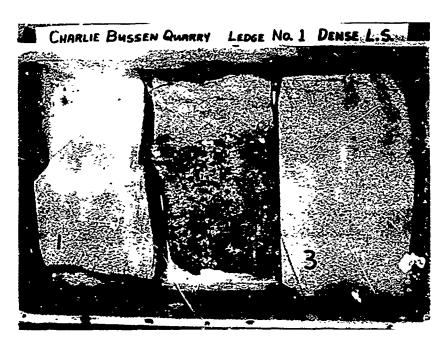
	Height of B	low at Failure, cm
	Perpendicular to Plane	Paralog to Plane of
Test No.	of Structural Weakness	Structural Weakness
1	8	7
2	6	10
3	6	8
Avg	7	8

# Freezing and Thawing in Water and Alcohol (CRD-C 144):

Type of	Specim <b>e</b> n	Original OD wt.	of fra Large 25 %	OD wt.  Than  in the control of the	Wr Loos During	Cycles	
<u>Stone</u>	No.	<u>8</u>	<u>s</u>	7.	7 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Completed	
Dense	1	4932	4925	99.9	0.1	20	
Limestone	2	4722	4719	99.9	0.1	20	
	3	4319	4300	99.6	0.4	20	
}	Avg				0.2		

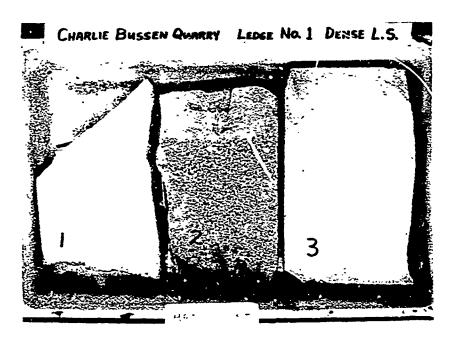
#### Riprap Data Sheet

After 20 cycles of freezing and thawing the following observations were made of samples STL-19 G-4(A) through G-4(D). There was little effect on any of the rock tested except the shally pieces of ledge 4C. Two of the shally pieces showed spalling and cracking along hedding planes. The rock of the slabs from ledges 4A through 4D was like the rock from the Stotz Quarry (STL-19 G-3(A), G-3(B)), in appearance, but there were less effects of the test visible on the Dussen rock slabs.



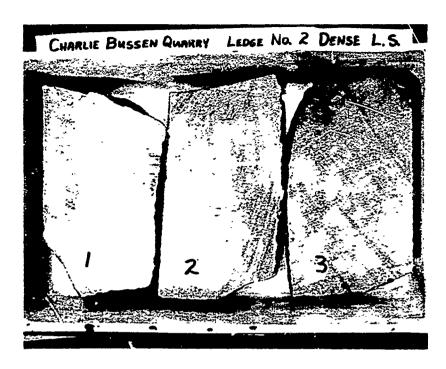
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a. Before test

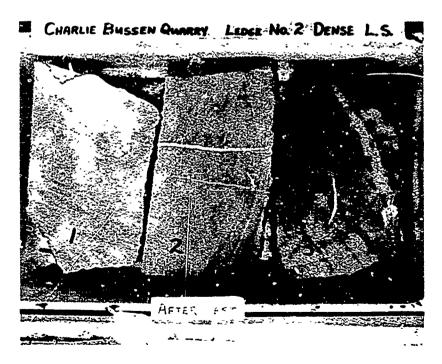


b. After test

Fig. 4A. Bussen Quarry stone from ledge No. 1 tested for freezing and thawing in an 0.5 percent solution of water and alcohol.

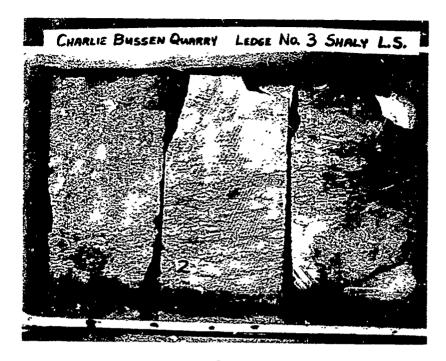


a. Before Test

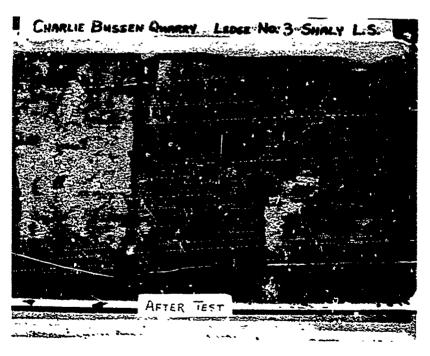


b. After test

Fig. 4B. Bussen Quarry stone from ledge No. 2 tested for freezing and thawing in an 0.5 percent solution of water and alcohol.



a. Before test

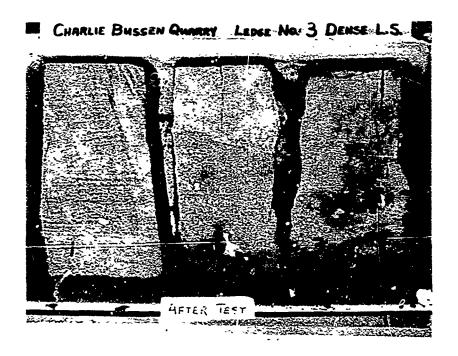


b. After test

Fig. 4C. Ruscen Quarry stone from ledge 3 tested for freezing and thawing in an 0.5 percent solution of water and alcohol.

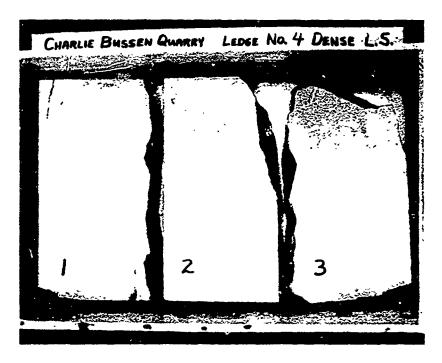
and and and alkumas emperaturated control of the series of the second of the series of

a. Before test



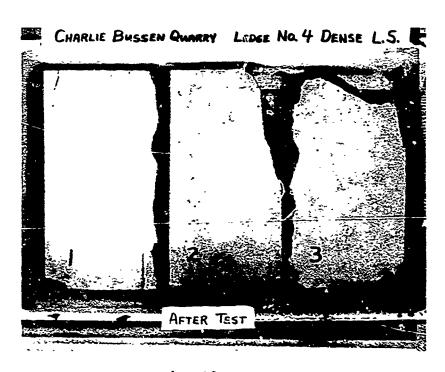
b. After test

F'6. 4D. Bussen Quarry stone from ledge 3 tested for freezing and thawing in an 0.5 percent solution of water and alcohol.



a. Before test

canacal echanical representation of the control of



b. After test

Fig. 4E. Bussen Quarry stone from ledge 4 tested for freezing and thawing in an 0.5 percent solution of water and alcohol.

TATE.	· · · · · ·	u.ri	ING	:X NO:			<i>2</i>	PRAP	TES	770 6Y						
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SIEVE	3-6"	13-3"	3-15"	w4-3"	FINE AGG.	2111 1 52	C0 C	SURF DRY (	'C20-C	107 1043				(c)	12 6	
GIN.	<del> </del> -							CENT (CRD-							10 8	
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314.						PER CEN	T LIGHTE	R THAN JP.	. ca	_(CAD-C I	29):					<u> </u>
įι.			!			<del></del>		ADM ELCHGA								<u> </u>
2 IN.		<u> </u>	<u> </u>					.055, 5 CYC.			4 - <del>5</del> )	(CRD-	C 115)	<u> </u>	<del> </del>	<u>.</u>
į ΙΝ.	<u> </u>	ļ				<del>!</del>		L A),%,(		117):			<del></del>	<u> </u>	35.4	
1 IN.	<del> </del>		<del> </del>	ļ	<del> </del>		<del></del>	FT (CRD-C				<u> </u>	:	<u>!</u>	<u>-:63.2</u>	:
1 IN.	<del></del>	<del> </del>	<del>                                     </del>	<b> </b>				(CRD-C E, % (CRD-					<del></del>		<u> </u>	<del></del>
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NQ 16						MORTAR	MAKING	PROPERTIE	S (CRD	- C 116)						
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F.M.(6	<u></u>	<del> </del>	<del> </del>	<del>                                     </del>	<del> </del>	1 -			-				<del> </del>		<del> </del>	<del></del> i
	i C 105	(b) C	AD-C I	04	<b>!</b>	MORTA	R:						1		1	
				-		L	<u> </u>	FINE AGO	GREGATI	:	Ţ		COARSE	AGG	EGATE	
ACRTAR	-BAR E	PANSIO	N AT I	DOF, %	- CRD	-C 123):	3 MO.	6 MO.	9 MO.	12 40	. 3	мо.	6 MC	) i o	MO.	ou s.
Low-	ALK. CE	T//3h		70 Na <sub>2</sub>	O EQU	IVALENT:										
ніСн-	جدلا 15	MENT:		% Na	O EQU	IVALENT:	<u> </u>				$\perp$			1		
		CONCA	ETE (CI	RD-C										inv	/-co ·	45-64
	AGG.					COARSE A						E 300	<b></b>	<del>- -</del>	<u> </u>	
FINE						COARSE A	17,00				OF	E 300	I	l _	L	

PETMARKS: \* The number to the left is the height of the blow at failure in cm, perpendicular to the structural weakness and the number to the right is the height of the blow parallel to the structural weakness of the sample.

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AN THE STATES AND THE PROPERTY OF THE PROPERTY

Riprap Data Sheet Concrete Division P. O. Drawer 2131

Jackson, Missitsippi Project Kaskaskia River, Illinois, Navigation Improvement Date

Vicks-35 G-1(2) , Ledge Pack, Monegar Ovarry

May 1955

	Height of 1	Blow at Failure, cm
	Perpendicular to Plane	Parallel to Plane of
Test No.	of Structural Weakness	Structural Weakness
1	4	4
2	5	4
3	5	5
Avg	5	4
1		

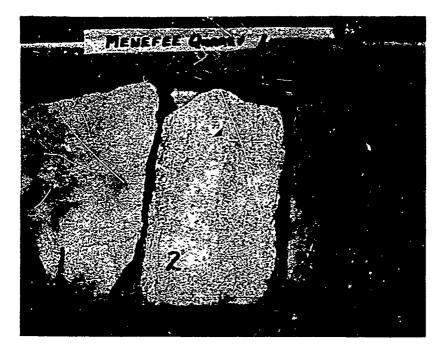
## Freezing and Thawing in Water and Alcohol (CRD-C 144):

Type of	Specimen	Original OD wt.	Final of Fra Larger 25 % o Origin	gments Than f	Wt Loss During	Cycles
Stone	No.		g	7.	Test, 7	Completed
Dense	1	4034	4077	99.8	0.2	20
Limestone	2	4238	4232	99.8	0.2	20
	3	4501	4492	99.8	0.2	20
	Avg				ა.2	

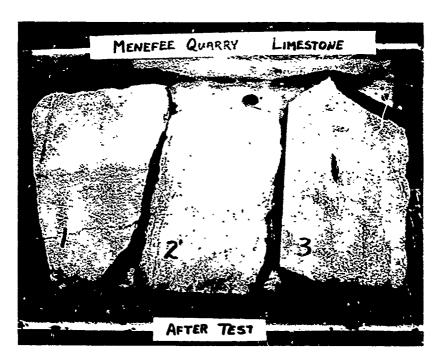
## Riprap Data Sheet

After 20 cycles of freezing and thawing according to CRD-C 144 the following observation was made:

No effects of the test were apparent on the rock slabs.



a. Before test



b. After test

Fig. 5. Menefee Quarry stone tested for freezing and thawing in an 0.5 percent solution of water and alcohol.

STATE: N	lisse	uri	CMI	X NO.				REGATE									
LAT. 3	37		LON	G	39		DATA	SHEE		DATE	_May	126	5				نـــــ
LAB SYM	BOL NO	s: s'	TL-19	)_G-1				7	YPE	OF A	aat eria	٠. :	22.5	1.4.1		<u> </u>	
LOCATION	:_Sc	c 11	. R 1	12 E.	T	35	.urxy										
Misso																	
							Box 3	3. Per	rys	ill	e. M	isso					
SAMPLED	BY. S	t. L	ouis	Dist	ric												
TESTED	FOA: K	aska	skia.	Rive	<u>ب</u> عد	Uling	nis. Na	vigati	on.	Imp	rove	nent					
PROCESSI	NG BEF	ORE I	STING:	Crus	hins	anc	separa	tion i	nto	Lsi	zes						
						<u> </u>											
																	i
GEOLOGIC	AL FOR	MOTAM	AND	AGE:	Plat	tin_	limesto	ne, Mi	dd.	Le C	rdov	ننعن	20_A	ge			
<u></u>					<u>.                                    </u>	·	· · · · · · · · · · · ·							·			
GRADING	(CRD	- C 103)	(CUM.	70 PAS	SING).	ĺ	TE	ST RES	UL.	TS			3-6"	11-34	-13" *4	ء ' ۽ ڊ ـ	'araz i
SIEVE	3-6"	1}-3"	3-14"	w4 - 3"	FINE	<u> </u>									1	<u> </u>	AGG
		,			AGG.	BULK SI	P. GR , SAT S	SURF DRY	(CRD	-C 1	07,108):			2.703	712	<u>711</u>	
GIN.						ABSORP	TION, PER C	ENT (CRD-	CI	7,108	3):			1.4 1	لمنتقم	2 !	
5 IN.						CRGANIC	MPURITIE	S, FIG. NO	(Cr	D-C	121).				!_	<u> </u>	i
4 IN.		100				1	ARTICLES,				30):			0.0 2	0.0.	<u>. '-</u>	:
31N.		95		<u> </u>			NT LIGHTER				(CRD-C I				;	- , -	
2 IN.		-				PER CEI	NT FLAT A	O ELONGA	TED	(CRD	-C 119,1	20):		3,0 5	1 5	3 !	
2 IN.		38	100		l	WEIGHT	ED AV. % LC	SS, 5 CYC	MgS	O4 ((C)	) <u>÷ · (* •</u>	4- ;;(	CHD-	C 115)	5.	<u>6</u>	
1 ½ IN.		5	95			ABRASIC	. LOSS (L	A),%,(	CAD	-C 11	7):			20.83	1 2 2 1 X	3:-	
IIN.		2	32	100	L	UNIT W	T., LB/CU F	T (CRD-	. 10	6):				İ ;_			
₹ IN.			5	95		CLAY L	UMPS, % (	CRD-C 11	B)								 i
ĮIN.				-		COAL A	ND LIGNITE	, ‰ (CRD	-c	22):				-		<u>—:</u>	
} IN.			2	38		SPECIFI	C HEAT, BT	U/LB/DEG.	F. (	CRD-	C :24):					i	
NO 4				2	<u> </u>	REACTI	VITY WITH	NoOH (C	RD-	C 156	3): 5c,~	W/L			:		
NO. 6	1					1					Rc, ~	M/L				1	
NQ.16		1				MORTAF	R-MAKING I	PROPERTIE	s (c	RD-	C 116)						
NO. 30						TY~E_	СЕМЕ	NT, RATI	<u></u> ن	0	AYS,		<b>~</b> ,	0	AYS,		7.
NO.50						LINEA	THERMAL	EXPANS	ON	XIO S	OLG. F.	(CRD	-C 15	5,.26)			
<b>%0 100</b>	i	i T				1 [	ROCK	TYPE		PAR	ALLEL	AC	1055	CN	1 A:	/ERAG	<u> </u>
NO.200						1 [								1	<del>-</del>   -		
- 2006-	1		i			: :								!			—; ·
F.M.(b)	1	i			-									1			
(+) CRD-	C 105	(p) Ci	10-C	104	<del>,                                     </del>	M. PT	AR:										
							.	FINE AG	GRE	SATE		T		COARSE A	CGAEGA	٠. ت	
MORTAR-	BAR E	XPANSIO	N AI I	00F, 7	6 (CHD	-6 .233	3 MO.	6 MO.	9	MO.	12 MC	. 3	MO.	6 VO	1 9 VO		vo
LOW-	ALK CE	MENT:		% Na	O EQU	IVAL THE	<u> </u>	!			Ĭ	J		L	!		
н:Сн-	ALK.CE	MENT:		% Na	O EQU	IVALE-IT	:									1	
SOUNDN	ESS IN	CONCR	CTE (C	RD-C	40, 114	ı):								1 667		2 42	) - C &
FINE	AGG. E	٦٠-٦	S=31	(4)		COARSE	AGG: ST	L-19 G	-1			DF	200	81	1	<del></del> -	
FINE	AGG.		. حد ـ د	L		COARSE		=×			•	DF	E 300	. <del></del>	1		
PETROGE	RAPHIC	DATA	(CRD-	C 127):						,				<del></del>			
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	<b>U.</b> :	S. ARKY		SOUNEVE	ESS TEST		i, Missi.	
Trower	Miss.	<u>Valley</u>	DIVISIO	M (CRD	-C 115)			
YVEOL STL-		1.0.		<u></u>	<del> </del>	MATUR AL		
Job No. 6	624	Kas		liver Nav.	Imp.	<u> </u>	limesto	one
STL-19 C-	.1			ver Rock	Co., G:	zar Quari	ry, Parry	wille, Missour
<del></del>	<del></del>	<del></del>	<del></del>	<del></del>	STAPBOATE	~ 3		,
S!EVE SIZE	GRADING FOR CALCULATION	FRAC	GHT OF TEST TIONS BEFOR ST (Grams)	NE.GHT CHE FRACTIONS TOST (G	AFTER : AFTE	R TEST		TER TO ME CONTEST AND CONTEST AND PER CENT LOS
3.26	(Per Cent)	0.41			ACTO	L (CSS (9)		LOSS   PER CENT EUS
.0.4 TO 1 IN	5C	7:				<u>ئەيۇك چ</u> ى		7.5 . 2.55 . 3.75
1 TO 1 IN	50 TOTAL	150 s 22°			412.7 100		ئى، ئامىلىك	5.5 . 3.65 . 2.90 - 1.5.50 6.65
							21 A B 15	3 2 113 25 1
				NG. Cř. i	AVG TOTAL	. až R-TFC	4.0 -, 45 ]	F 2 6 P 4 215
	CONSTITU	ENT		PANTICLES L	SPLIT CRU		T CLES AFT	R TEST
	(Size ¾ to	in.)	_	RUN REN RE	UN   RUN   RUS	RLN   RLN	RUN KUN I	RUN RUN - RUN RUN RU
Limestone	<del></del>			42,42	$\frac{1}{1}, \frac{2}{1}, \frac{1}{3}$	2 0	2;:	2 , 1 2 2 3 · 23 25 · 42 4
			Kep best	roduced from				
				roduced from available co	ру.	- <del> </del> <del> </del> ;	·	
	11			<u> </u>	MOGRECATE	•		·
SIEVE	GRADING FOR CALCU-	FRACT	AT OF TEST CIONS BEFORE ST (Grams)	E FRACTIO	OF TEST ONG AFTER 'Grams)	S.EVE AF	NG FINER TER TEST % Was	NEIGHTED AVERAGE
	LATION (%)	RUN 1	RUN 2	RUN I	FU1 2		24.2	<u> </u>
78-INNO.4	<del> </del>				<del>!</del>	ļ	<u> </u>	<del> </del>
G. 4-8	13				<del> </del>	:	<del></del>	
0. 16-30	20		·i			1		<del></del>
.0. 30-50	24				ļ			• —————
0. EG-100	7	•	<del></del>	<del></del>	<del>                                     </del>	0.0 c.5	. c.o	2.3 2.5
TOTALS	100				<u> </u>	L	<u> </u>	
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				A:	VG TOTAL NE	IGHTED AVG	F. 5 1 8 2	PER CLY
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COA-SE BY		o	ATE OF REPO					
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COMPUTED								
TINE BY					95			
COMPUTED					95			
INL BY CMPUTED					95			

				F 11.7	CGRECATE				
SIEVE SIZE	GRADING FOR CALCU- LATION	FRACTIO	F OF TEST NS BEFCRE (Grams)	FRACTIO	OF TEST NO AFTER 'Grams)	S.EVE AF	MG FINER TER TEST % 035	NE:GHTED COMMICTE	AVERAGE 1 5 AVERAGE 1 5 % LC /S
	(%)	RUN 1	RUN 2	RUN 1	5.4.2		-y1 2		
3/8-INNO.4	2 -				!	<u> </u>	!		
NG. 4-8	13				1	:			
NO. 8-16	20		i		<del></del>	1		;	
NO. 16-30	2÷					1	1	1	
·O. 30-50	24	•	1		Ţ. ——				··
1.0. EG- 100	14	•	•			0.0	C.S	, = 2.7	2,5
NO. 100- PAN	7	•			1 •	C.5	. c.ó ·	3.0	5.8
TOTALS	100						!		
					SUM NE	کید دی۔ ہیں	s_ (5 :		
				AV	G TOTAL NE	IGHTED AVG	F. 5 1 8 2		PER CENT

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GRADING (CAE	D- C 103	)(CUM.	70 PAS	rive):		TE:	ST_RES	ULTS		3-6	15-3	} -: £*	-4-3	FINE
SIEVE 3-C	414-30	2-,10	ma-2"	FINE							1	`(c) <sup>'</sup>	(c)	AGG.
3.2.2	1,3		•	AGG.	BULK SP.	GR , SAT S	SUAF DAY	CRS-C I	07,108):	i	2.68	2.67	2.67	<u>. i</u>
6 IN.					ABSORPT	ION, PER C	ENT (CRD-	C 107,10	3)·		0.6	0.გ	່າຸດ	1
SIN.	1	<u> </u>			CAGANIC	IMPURITIE	S, FIG. NO	(CSD-C	151).		]==:		:	1
4IN.	100	:			SOFT PA	RTICLES,	PER CENT	(CRD-C	30):		2.9	3.6	2 6	
3IN.	95		<del>                                     </del>	<del>                                     </del>	<del></del>		R THAN SP			25):		= - =		7-2-1
2 1N.	1 22	-	-				NO ELONGA				kg.3	74. 5		
2 IN.	+	100	$\vdash$	<del> </del>	<del></del>				<u>_</u>	4- ÷) (CRD-			**************************************	
1 ½ IN.		7	<del>:</del>	<del> </del>	<del></del>		A.),%, (				50.2	32 3		
	1 5	<del></del>			<del></del>					<del></del>	30	37.1	74	. —
I IN.	1 2	32	100	<del> </del> -			TT (CRD-C				<del>├</del> !	—-	<del>!</del>	i
2 IN.	<del> </del>	<u> 5</u>	95	<u> </u>	<del></del>		(CRD-C 11				<u> </u>		<u>:</u>	<u></u>
IN.	<u> </u>	<del>  -</del>	<u> </u>				, % (CRD				!!	=	<u> </u>	·
3 IN.	<u> </u>	2	23	<u> </u>			WLR/DEG.				نسا		i	<u>:</u> :
K0 4		<u> </u>	1 2	<u> </u>	REACTIV	ITY WITH	NoOH (C	BD-C 15	s):   Se, r	u.z.;				
NO.8		<u>1</u>	<u> </u>	<u> </u>					Reym	W/L:			<u> </u>	<u> </u>
NQ.16		•			MORTAR-	-MAKING	PROPERTIE	S (CRD-	C 116)					;
NO 30				1	TYPE	CEME	ENT, RATIO		AYS,	<sub>-</sub> - <sub>3</sub> ,		DAY's.		~
NO.50	1	I			LINEAR	THERMAL	EXPANSI	ON XIG	DEG. F.	(CRD-C I	25,:26):			
NG 100	1	1	!		1 [	ROCK	TYPE	PAR	ALLEL	ACROSS	1 &		AVER	4GE :
NG.200	<del>                                     </del>	<del>                                     </del>	†	<del>!                                    </del>	1				<del>i</del>		T-	i		
- 2000		i	<del>                                     </del>	†—	1 -						<del>                                     </del>	بـ ـــــــــــــــــــــــــــــــــــ		1
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-) CRD-C 105					I month	1	EINE AC	CRECATE			COARSO	1555	SOATE	<del></del>
RAG-RATROM	EXPANSIO	TA HO	00F, 7	• (CRD	-C 123):	<del>  </del>		GREGATE		+	<del></del>			
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STL-19 0	;-2	%est	Lake	Quar	rry a	nd P	late	rial	.s C	o.,	Brie	dget	on,	Mis	55011	ri	
					COARS	AGG	HESAT	Ξ									_
SIEVE SIZE	GRADING FOR CALCULATION	WEIGHT FRACTION TEST (	S BEF	ORE ;Fi	NE:GAT RACT.O	15 AF	TER	HEIGH EINE EINE AFTEI AFTEI	TES		1	15	ŜŦ	` ¦	CGA	TED AVO RECTED ENT LOS	•
<u>-</u>	(Per Cent)	RUN 1	RUN		RUN I			F.4:							F.7.		
<u> </u>	50	<u> 750                                   </u>	75												7.55	7.4	Ū
1 TO 1 !N	<u> </u>	1500	150		318.							.1	11.	1.	<u>6.05</u>	5.5	<u>.5</u>
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									13% N	GHYE	AVG	RU-S	. 1 A	? [2	6.85	1	
							AVG 1	TOTAL	ne:G	TED.	AVG .	RINS	1 : :	2 i]	3.4	PER CE	4
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	(3)16 % 40 1 1/			RIN I	Ria 2	RLN	RUN 2	ma	RUN	fi.	. A. A	RUN	. ALA 2	KLN.	RLA 2	HUR. R	بدن 2
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				FILE A	GGREGATE				
SICVE SIZE	GRADING FOR CALCJ- LATION	FRACTIO	OF TEST NS BEFORE (Grams)	FRACTIO	OF TEST NS AFTER (Grans)	SIEVE AF	NG FIRER TER TELT % LUSS	EEIGHTED COARLCIE	
	::4)	F.A. !	RJA 2	RLN 1	RUN 2	RUN 1	5.5.2	1 8,8	KAN I
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.S. ES. :00	, 14	•	: -			C.3	0.0	0.0	0.0
VO. ::32- PAN	. 7	•				6.0	0.0	0.0	5.0
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PRODUCCIA: State Outs Outsty   Prairie du Rocher, Illinois   Produced
CECLOGICAL FGASMISM AND AGE: Solom limostone, Motives group, Middle Nississippien   Age
CECLOGICAL FGRIVATION AND AGE: Solom limostome, Metamec group, Middle Nississippion   Age   Ag
CECLOGICAL FGAS-ATISM AND AGE: Salom limostone, Motives group, Middle Nississippien   Age   Ag
CECLOGICAL FGASMISM AND AGE: Solom limostone, Motives group, Middle Nississippien   Age
CECLOGICAL FGRIVATION AND AGE: Solom limostome, Metamec group, Middle Nississippion   Age   Ag
CRADING (CAD-C (C3)(CUN To PASSING):   TEST RESULTS   15-3   15
GRADING (CRD-C 103)(CUM TO PASSING):  SIEVE 3-6" 13-3" 2-13
CRADING (CAD-C (C3)(CUM TO PASSING):   TEST RESULTS   15-3
TEST RESULTS
SIEVE 3-6" 13-3" 2-13" 11-13"
SIEVE   3-6   3-7   3-12   AGG   BUEN SP. GR., SAT SURF DRY (CRD-C 107,105)   2.65
61N.   ASCAPTON, PER CENT (CRD-C 107,106)*   0, 4   0, 5   0, 7    51N.   ORGANIC INPURITIES, FIG. ND (CRD-C 120)*   O, 10, 6   10, 7    51N.   1(10)   SOFT PARTICLES, PER CENT (CRD-C 120)*   O, 10, 6   10, 7    51N.   95   PER CENT LIGHTER THAN SHOR_ (CRD-C 120)*   O, 10, 6   10, 7    52N.   30   100   WEIGHTED AV. \$2, 2055, 5 CYC. Mg5Qg (10 ½ - 17, 40 ½) (CRD-C 115)*   2, 8    52N.   30   100   WEIGHTED AV. \$2, 2055, 5 CYC. Mg5Qg (10 ½ - 17, 40 ½) (CRD-C 115)*   2, 8    52N.   2   30   100   UNIT AT., LB/CU FT (CRD-C 106)*   25, 3132, 8    52N.   2   30   SPECIFE HEAT, STU/LB/DEG, F. (CRD-C 124)*    51N.   2   30   SPECIFE HEAT, STU/LB/DEG, F. (CRD-C 124)*    NO.4   1   2   REACTIVITY WITH MODH (CRD-C 128)*   Segment.    NO.4   1   2   REACTIVITY WITH MODH (CRD-C 128)*   Segment.    NO.50   MORTAR-MAKING PROPERTIES (CRD-C 115)*    NO.50   LINEAR THERMAL EXPANSION XIO 7 MG. F. (CRD-C 123,126)*    NO.50   LINEAR THERMAL EXPANSION XIO 7 MG. F. (CRD-C 123,126)*    NO.50   ROCK TYPE   PARALLEL ACROSS   CN   AVERAGE    10 CRD-C 105   (6) CRD-C 104   MORTAR:  11 MCGTAR-BAR EXPANSION AT 100F, 76 (CRD-C 123)*    12 MCGTAR-BAR EXPANSION AT 100F, 76 (CRD-C 123)*    13 MG.   6 MG.   1 MG.   1 MG.   2 MG.   3 MG.   6 MG.   5 MG.   5 MG.   7 MG.    14 MCGTAR-BAR EXPANSION AT 100F, 76 (CRD-C 123)*    15 MCGTAR-BAR EXPANSION AT 100F, 76 (CRD-C 123)*    15 MCGTAR-BAR EXPANSION AT 100F, 76 (CRD-C 123)*    15 MCGTAR-BAR EXPANSION AT 100F, 76 (CRD-C 123)*    15 MCGTAR-BAR EXPANSION AT 100F, 76 (CRD-C 123)*    15 MCGTAR-BAR EXPANSION AT 100F, 76 (CRD-C 123)*    15 MCGTAR-BAR EXPANSION AT 100F, 76 (CRD-C 123)*    15 MCGTAR-BAR EXPANSION AT 100F, 76 (CRD-C 123)*    15 MCGTAR-BAR EXPANSION AT 100F, 76 (CRD-C 123)*    16 MCGTAR-BAR EXPANSION AT 100F, 76 (CRD-C 123)*    17 MCGTAR-BAR EXPANSION AT 100F, 76 (CRD-C 123)*    18 MCGTAR-BAR EXPANSION AT 100F, 76 (CRD-C 123)*    19 MCGTAR-BAR EXPANSION AT 100F, 76 (CRD-C 123)*    10 MCGTAR-BAR EXPANSION AT 100F, 76 (CRD-C 123)*    10 MCGTAR-BAR EXPANSION AT 100F, 76 (CRD-C 123)*    10 MCGTAR
SIN. 1(.0) SOT MATICLES, FIG. NO (CAD-C 121)
SOFT PARTICLES, PEH CENT (CRD-C 130):   O 0 10 6 10 0   O 10 6 10 0
210.   95   PER CENT LIGHTER THAN SP.GR(CAD-C 122).
PER CENT FLAT AND ELONGATED (CRD-C 119,120).   0.4   1.6   2.5
2 IN.   33   100
1   1   2   3   1   2   2   3   1   2   2   3   1   2   3   3   3   3   3   3   3   3   3
1   1   2   12   100
\$10. 5 95 CLAY LUMPS, % (CAD-C 118)  \$10.
\$10.
1
NO.4   2   REACTIVITY WITH MOOH (CRD-C 128)   ScymM/L
NO.8   NO.8
MORTAR-MAKING PROPERTIES (CRD-C 115)  NO 30
NO 30   TYPE CEMENT, RATIO DAYS Q DAYS, %  NO 50   LINEAR THERMAL EXPANSION XIC 900 F. (CRD-C 125,126).  NO. 100   ROCK TYPE PARALLEL ACROSS ON AND ACC NO. 200 F. MORTAR:  F.M. 100   MORTAR:  MCRTAR-BAR EXPANSION AT 100F, % (CRD-C 123): 3 MO. 6 MO. 5 MJ. 12 MO. 3 MO 6 MO. 9 MO. 12 MO. 100 MORTAR:  LCW-ALA, JEMENT: % NO 20 EQUIVALENT:  MCGCARCE (CRD-C 40, 114): FET NW-CO NO-CW
NO 50   LINEAR THERMAL EXPANSION XIC 1900 F. (CAD-C 120,120).  NO. 100   ROCK TYPE   PARALLEL   ACROSS   CN   AVERACE    NO. 200   ROCK TYPE   PARALLEL   ACROSS   CN   AVERACE    F.M. 100   ROCK TYPE   ACROSS   CN   AVERACE    F.M. 100   ROCK TYPE   ACROSS   CN   AVERACE    F
NO.200:  NO.200:  - 200 <sup>67</sup> F.M. <sup>107</sup> (a) CRD-C 105 (b) CRD-C 104 MORTAR:  MCRTAR-BAR EXPANSION AT 100F, % (CRD-C 123):  LCW-ALA. JEMENT:  % No.20 EQUIVALENT:  HIGH-ALA. JEMENT:  % No.20 EQUIVALENT:  SCUNDNESS IN CONCRETE (CRD-C 40, 114):  FET NW-CD ND-CW
NO.26C:  - 200 <sup>67</sup> F.M. <sup>60</sup> (a) CRD-C 105 (b) CRD-C 104 MORTAR:  MORTAR-BAR EXPANSION AT 100F, % (CRD-C 123):  - 200 <sup>67</sup> - 200 <sup>67</sup> MORTAR-BAR EXPANSION AT 100F, % (CRD-C 123):  - 3 MO. 6 MO. 5 MJ2 MO. 3 MO. 6 MO. 15 MJ2 VO.  - 100 - ALA, CEMENT: - % No.20 EQUIVALENT:  - 100 - ALA, CEMENT: - % No.20 EQUIVALENT:  - 100 - ALA, CEMENT: - % No.20 EQUIVALENT:  - 100 - ALA, CEMENT: - % No.20 EQUIVALENT:  - 100 - ALA, CEMENT: - % No.20 EQUIVALENT:  - 100 - ALA, CEMENT: - % No.20 EQUIVALENT:  - 100 - ALA, CEMENT: - % No.20 EQUIVALENT:  - 100 - ALA, CEMENT: - % No.20 EQUIVALENT:  - 100 - ALA, CEMENT: - % No.20 EQUIVALENT:  - 100 - ALA, CEMENT: - % No.20 EQUIVALENT:  - 100 - ALA, CEMENT: - % No.20 EQUIVALENT:  - 100 - ALA, CEMENT: - % No.20 EQUIVALENT:  - 100 - ALA, CEMENT: - % No.20 EQUIVALENT: - % No.2
- 200
F.M. O. (a) CRD-C 105 (b) CRD-C 104 MORTAR:  MCRTAR-BAR EXPANSION AT 100F, 76 (CRD-C 123): 3 MO. 6 MO. 5 MJ. 12 MO. 3 MO 6 MO. 5 MJ 12 VO  LOW-ALK CEMENT: 76 No. 20 EQUIVALENT: 1
Color Color   Color Color   Color Color   Color Color   Color Color   Color Color Color   Color Color Color Color   Color Co
### AGGREGATE CCARSE AGGREGATE  ###################################
### MCATAR BAR EXPANSION AT 100F, % (CRD-C 123):    3 MO, 6 MO, 5 MJ, 12 MO, 3 MO 6 MO, 15 MJ 12 MO   LOW-ALK, CEMENT: % No2O EQUIVALENT:
3 MO, 6 MO, 12 MO, 13 MO 6 MO, 15 MO 12 MO 13 MO 6 MO, 15 MO 15
NICH-ALA, CEMENT: % No 30 EQUIVALENT:  SGUNDNESS IN CONCRETE (CRD-C 40, 114):  FET NW-CD ND-CW
SOUNDNESS IN CONCRETE (CRD-C 40, 114): FET NW-CD HD-CH
currence No. at 1 No. 18 to 1 no. 1
FINE AGG. S-2-3 STG-1 COARSE AGG: STG-19 G-3 DFE soo F1
FINE AGG. " UFE 300
PETROGRAPHIC DATA (CRD-C 127):
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REMARKS:
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WES FORM 726 JAN. 1951 $98$

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SIEVE CALCU- TEST (Groms)	FRACTIONS AFTER TEST (Greens)	SIERL AFTER TEST ACTUAL % LOSS	SE.GHTED AVERAGE CORRECTED % LOSS	3
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. 100. PAX 7		3.0	3.0   3.6	4
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SIEVE	3-6*	·j-3"	3-15"	-c-}-	FINE AGG	BULK SP	CA, SAT	SURF DRY	(CRD-	C 10	7,106):	+	2.62	(c)	(c)	AGG
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				FINE A	GGREGATE				
SIEVE SIZE	GRADING FOR CALCU- LATION	WEIGHT OF TEST FRACTIONS BEFORE TEST (Groms)			OF TEST NS AFTER (Grams)	SIEVE A	ING FINER FTER TEST L % LOSS	WEIGHTED CORRECTE	
	(%)	PIN 1	RUN 2	RUN 1	RUN 2	RUN 1	Ruti Z	RLN 1	1 SUN 2
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	<del></del>			AV	G TOTAL WE	ICHTED AVG	RUNS 1 & 2	i	PER CENT

REMARKS		•	
CCAPSC BY JEJ	CHECKED RIN		
CCARSC PY JFJ	CHECKED RIN DATE OF REPORT May 1965		

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SIA	[ ] ] <u>i</u> ;	<u> pris</u>	INC	F NO	l	3	AGG	REGAT	E 11	STED BY	1!\$4	EU	88			
A	37		ان	Nu.	89		DATA	SHE	T 0/	re:	May	1	96°_			
LAD SYN	I COL N	<u> </u>	7,-5	<u>s-20</u>	<u> </u>		<del></del>		TYPE C	IN TAN	AL Nat	ur	<u>al_5/</u>	ind_		
	,	្រូកវត្	sinn	i_Si	very	<u>et Sho</u>	ater,	Illin	ois.	NE 1	4, Sc	c	24, 7	7 9	<u>.                                    </u>	
						llinoi		····		<del></del>	<del></del>					
PRINCIPLE	S	uthe	rn_I	llin	ois.	Sand C	oC!	cster	_111	inois						
5 A A A GO # # #								<del></del>								
SAMPLED TESTED	EO3	بايج	Font	a_Di:	atri						<del></del>					
PHUCESS	INC. BEE	Kesk	<u> CSXX</u>	a_Riv	ver.	LLLin	لمعنصا	iaviga	tion	Improv	<u>cement</u>					
			231140	Line	e			/	Rec			<b>-</b>				
							<del></del>	L	besi	duced from						
CEOLOGIC	CAL FOR	MATIO	AND	AGE.		·		<del></del>		ailable"	SON.		<u> </u>			
			· · · · · · · · · · · · · · · · · · ·	<del></del>							SPY.	ø	<b>)</b>			
GRADING	(CAD	- C 103	(CUM	70 PAS	SING)	r—–	TE	ST RE	SUI T		ŀ	$\overline{}$				FINE
				1	FILLE	; [	ے.			נ	3.	. 0 .	14-3"	(c)	₩4 - ₫ (c)	AGG.
SIEVE	3-6	13-3"	2-15	-4-3"		BULK SP	GR , SAT	SURF DAY	(CRD-	107,108	F	_				2.63
61%	i			i —		7	ION, PEH C									0.4
SIN.				1		<del></del>	IMPURITION									5*
4in						SOFT PA	ARTICLES,	PER CENT	(CRD-	C (30):		-				1-
3in.				<u> </u>		PER CEN	T LIGHTE	A THUN S	P. CA	(ORD-C	129),					1=
2 j IN.				1		PER CEN	T FLAT A	NO ELONG	ATED (C	RD-C 110,	120):	_				1
2 IN						WFIGHTE	D AV. % L	055, 5 CY	. Mg504	((c) } -1°,	4-1)(CR	0 - 0	115)			
1 \$ 1%.		i				ASRASIO	N LO55 (I	A.),%,	(CAD-C	: 117):						
1 IN.						UNIT WT	., LB/CU	FT (CRO-	C 106)							1
ŽIN.						CLAY LL	JMPS, %	(CRD-C	10)							1
j N						COAL AN	D LIGNITE	, % (CR	)-C 122	·):		-				
3 IN.				i	100	SPECIFIC	HEAT, BT	WLB/DEC	. F. (CR	D-C 124)						
NO 4							ITY WITH									1
NQ. 8					85						mM/L:					
NQ.16					65	MORTAR	- MAKING	PROPERTI	ES (CRI	) - C (16)						
NG 30							CEM							DAYS,_	_: 9	
<b>40</b> 50			l		1	LINEAR	THERMAL	. EXPANS	ION XI	o 4deg. F	. (CPD-C	: 12	5,126):			
P-0 100					1		ROCK	TYPE	P	ARALLEL	ACROS	3.5	04	•	AVER	ACE
NO.20G		ĺ														
- 20/ <sup>/41</sup>																
F.M(b)					3.10											
(e) CPD-	C 105	(P) Cb	D-C	04		MORTA	я:									
MORTAR -	BAR EX	PANSIO	N AT I	00F. 74	. (CRD	-C 153):		FINE AC	GREGAT	Έ			COARSE	AGGRE	GATE	
							3 MO.	6 MO.	9 44	). 12 M	). 3 M	<u> </u>	6 MO.	. 0	MO.	12 MO.
	LM CEN					VALENT:	ļ									
	ALH CEN					VALENT:	<u> </u>	<u> </u>	L							
SOUNDNE		CONCAI	TTE (CF	90-C				<del> </del>					FET	HW-	· C D	HD-CW
FINE A						COARSE A					DFE 30	-				
FINE						COARSE A					OF E 30	•				
							116)*									
Co	mbina						and ST								_	
				-	per	cent :	(HOEN		day.	$\frac{34.5}{34.5}$	$\frac{\Omega}{2}$ ,	/ 0	icys	518	() -	
		Ü	nwas	hed				3	day	s 348	<u>o</u> ,	/ C	lays	222	<u>( ·                                     </u>	
			_			_	•		•				•			
			Pe	rcen	t of	washe	ed	3	day	s <u>10</u>	1.	/ C	ays	10	1	
n÷	ranie	: :	urit	ins.	Pia	. Ma.	after	washi	ភាញ ឃា	ith 3	percer	:t	solu	tion		
				-			21): 2					-		•••		
REMARKS	;; ,			٠,	2	בורת ה	7 131-	. 57 ms	 '~~-1	Cana	floor	₹^	n Ann	****		
							.e. 1:									:
	- /							4-7114			1141					

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	nc. 89		DATA	SHEE			May 19				
AL SYVIAL NO. STL-19		<del></del>					<u>. Batu</u>				
GCAT ON 2-1/2 miles	SWof	vansvi	ille. I	llinoi	Rn.	adolp	h_Count	لسبت	عننن	حنم	
27.57.46.70											
ROSUCER RUTE Aspin	ilt Co.	Ruma	Illino	ris							
AND DE CALLE	D1 1						<del></del>				
ESTED FOR Waster and											
FOCESSING BEFORE TESTING	KIVEY.	TITING	DIR. No	MIGHE	On Im	DIOVE:	nent				
	NO 116						<del></del>	· · - · · ·			
			··								
TOLOGICAL FORMATION AND	AGE Res	dual (	Cypress	sands	tone.	uppe	r Missi	ssin	nian	1.20	
٤				، سندهس			XA	THAP.			
GRADING (CRD-C 103)(CUM	To PASSING)		TE	ST RES	ULTS		1,	13-3	3 - 12		
SIEVE 3-6" 13-3" 2-13	FINE		<del></del>	<del></del>				,,-3	(±)	(c)	14 %
3.6.6	AGG	BURLK SP	GR , SAT :	SURF DAY	CAD-C	07,108):				i_	2. 3
6:30		ABSORPT	ION, PER C	ENT (CRD-	C 107,10	e).				i	
SIN.			IMPURITIE							<u> </u>	<b>_</b> ⋮
4 IN	<u> </u>		MATICLES,							<u> </u>	上二
3IN.	<u> </u>		IT LIGHTER							<u> </u>	<u> </u>
2314.			T FLAT A					<u>i</u> _		!	<u> </u>
2·N	<del>                                     </del>	<del></del>					- <del>(</del> ) (CAD-	C 1:5)	ļ	<del> </del>	
1 § :N.	<del> </del>	<del></del>	N LOSS (L			17):				↓	
1N.		<del></del>	., LB/CU f		<del></del>			<u> </u>	<b>!</b> -	╄	<del></del>
₹1N.		<del></del>	мрз, % (					<u> </u>	<u> </u>	<del> </del>	- <del>-</del>
31N.	<del>  </del>	<del></del>	D LIGNITE						_	<del>!</del>	<del></del> -
₹:r.			HEAT, BY					<del> </del>	<del> </del>	┼	<del></del>
106		-	with with	HOOM (C	NO-C 12	Rc,m		<del> </del> -		┼	
1016	<del>-</del>	MOSTAR	-MAIUNG I	PROPERTIE	CRO-	<del></del>		ــــــــــــــــــــــــــــــــــــــ	L	<u> </u>	
••5 30	<del> </del>	_1			-	-	3 <u>-</u>		DAYS		%
NÚ 50 i	10						(CRD-C 12			==	
50.100	<del>  </del>	<del></del>	ROCK				ACROSS	<del>,</del>	N T	AVE	RAGE
NO 200	<del>                                     </del>	g						<del>                                     </del>	-		
- 2001-1	+	4 !				-		<del>                                     </del>			
L M(0)	0.2				-			1			
3-GR3 (a) CO1 3-GR3 (+)		MORTA	NR:					·			
				FINE AG	REGATE		T	COARSE	AGGR	EGATE	
MCRTAR-BAR EXPANSION AT	100F, 75 (CR)	)-C 123):	3 MO.	6 MO.	£ MO.	12 MO.	) MO	6 MC		MO	12 MC.
LOW-ALK CEMENT!	% No <sub>2</sub> O EO	UIVALENT:									
n Sh-Alk, Cement:	% No <sub>2</sub> 0 EQ	UTVALENT:						!			i
SOUNDNESS IN CONCRETE (C	RD-C 40, 11	4):						8 2 7	н₩	-co	HD-CW
FINE AGG.		COARSE A	AGG:				DFE 305				
FINE AGG		COARSE /	NGG:			•	DFE 300	<u> </u>			
PETROGRAPHIC DATA (CRD-	C 127):										
Constitu	ionts			Parc	ent C	<b>0</b> 7700	ition				
000030100				1616	CIIL C	ompos	1 ( 1011				
Quar	***				74						
Cher					10						
	spar				6	•					
	ellancou	s*			10						
		-			. •						
aconaes: * Include	s ricas,	carbo	nates.	horni	lende	, gan	net. ar	ıd va	riou	s 0	ther
tocks and minerals				10		. 0	٠, ٥.			_ \	
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WES FORM 726 JAN	. 1951										

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